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GUIDELINES FOR **ESTABLISHMENT AND MAINTENANCE OF FOREST WINDBREAKS** IN SERBIA

University Belgrade
FACULTY OF FORESTRY

Authors:

Ratko Ristic, Ph.D., Full-Time Professor

Boris, Radić, Ph.D., Part-Time Professor

Siniša Polovina, M.Sc., Assistant Lecturer

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Acronyms

NUTS	Nomenclature of Units for Territorial
AP	Autonomous Province
RS	Republic of Serbia
RSD	Serbian Dinar
USA	United States of America
PRC	People's Republic of China
FAO	Food and Agriculture Organization of the United Nations
SAPARD	Special Accession Programme for Agriculture and Rural Development
EU	European Union
GDP	Gross domestic product
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	The United Nations Convention to Combat Desertification
UNCBD	United Nations Convention on Biological Diversity
LDN	Land Degradation Neutrality
PPRS	Spatial Plan of the Republic of Serbia
RPPAPV	Regional Spatial Plan AP Vojvodina
DTD	Dunav Tisa Dunav irrigation system
ILSWE	The Index of Land Susceptibility to Wind Erosion
SDG	Sustainable Development Goal

GEF	Global Environment Facility
UNEP	United Nations Environment Programme
CO_2	Carbon dioxide
GIS	Geographic Information System
WEB	World Wide Web
GNSS	Global Navigation Satellite System
CAD	Computer-aided design
dxf	Drawing Exchange Format
shp	Shapefile

ANLA	American Nursery and Landscape Association
xls	file format for Microsoft Excel
UN Habitat	United Nations Human Settlement Programme
UN	United Nations
Š.Z.P	Forest windbreaks

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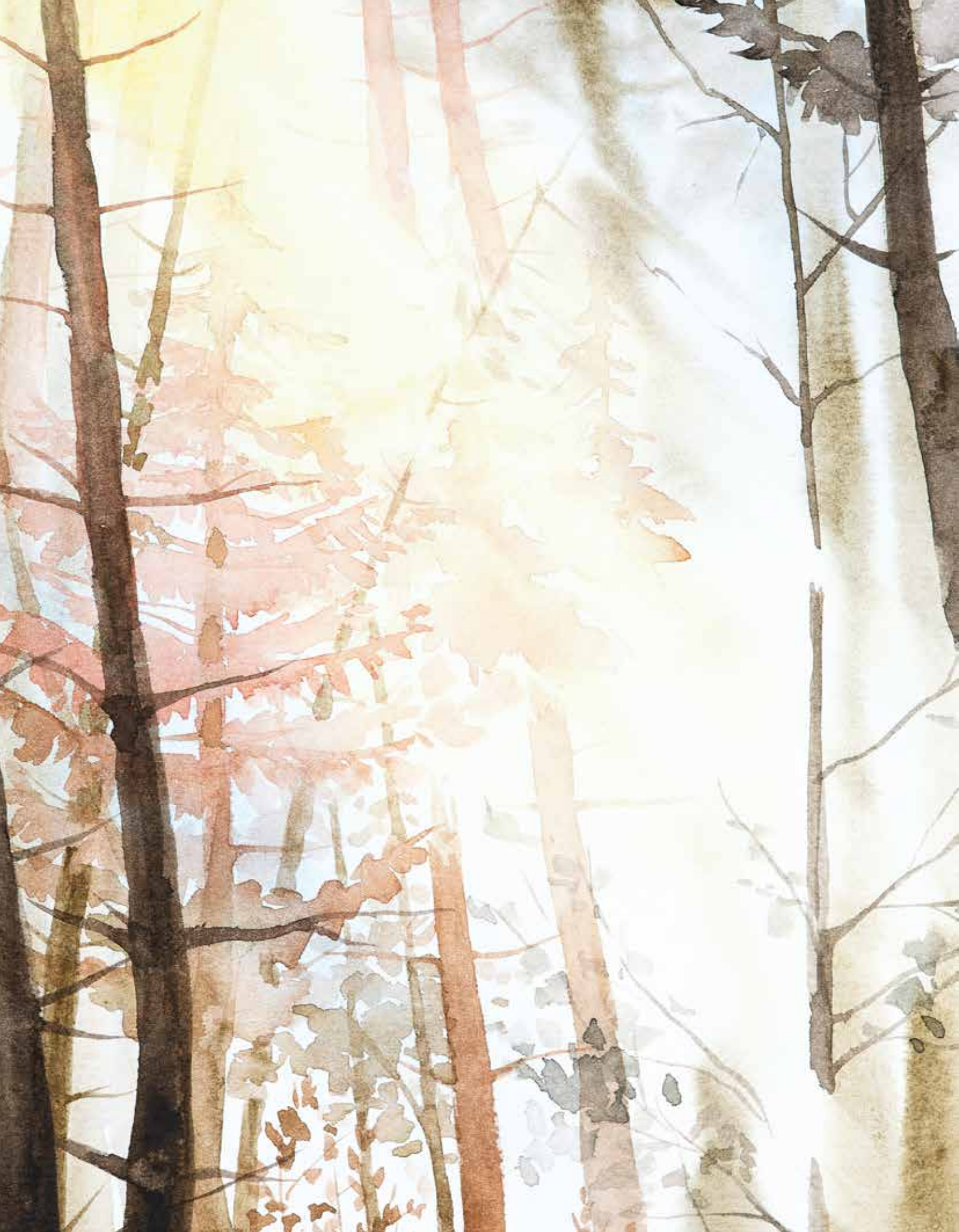


Summary

Protective windbreaks are an element of forest vegetation contributing to the state of the environment and reducing risks of hazardous phenomena and processes resulting in soil degradation. Their function is particularly significant in areas dominated by agricultural production, mostly without sufficient high vegetation, where wind erosion results in loss of soil fertility and increased risk of pollution and extreme climate phenomena. Additionally, protective windbreaks have a multifunctional value reflected primarily in improving and protecting biodiversity, linking rural and urban areas, protecting water bearing land, promotion recreational functions, etc. For the purposes of this document, the collected positions of relevant decision-makers and managers indicate unanimously the environmental value of forest protective belts (mitigation of effects of climate change, protection against wind erosion, improving biodiversity, establishing tourism-recreational contents, and the like). They also point to the need to come up with adequate models for financing the establishment and management of protective windbreak belts. In view of the relatively low level of afforestation in the Republic of Serbia, and with respect to unfavourable trends of climate and anthropogenic effects, protective windbreaks offer great potential as an instrument of environmental protection and increasing the level of afforestation. Although numerous spatial planning documents provide guidelines and obligations to increase the areas under forests, no major progress has been achieved so far in this respect. On the other hand, the legal framework declaratively recognises the relevance of protective forest windbreak belts and they have been recognised in a number of sectoral laws (forestry, agriculture, water management, environmental and nature protection). Legislation, however, does not prescribe a clear mechanisms for planning, financing, establishment and maintenance of such protective windbreaks belts. Based on a detailed analysis of the current situation, it has been concluded that the complexity, significance and multi-functionality of the system of protective windbreak belts requires specific legislation (laws, decrees, rule books), as well as the establishment of an independent management unit, in form of a public enterprise or a company, under the control of the Republic of Serbia, or a specific ministry. Financing activities related to protective belts (planning, design, implementation of works, maintenance) is possible from the national budget or international funds supporting nature protection and rural development, or from collecting fees from users of such belts.

1.

Detailed assessment of the status of forest protective belts in Serbia

1.1.

Introduction

Protective windbreaks are biophysical barriers reducing the speed of air movement (wind) thus reducing the intensity of wind erosion and unproductive evaporation, as a form of soil degradation. Windbreaks are planned plantations of trees and bushes in form of linear systems (corridors), which can also be in a form of network (with auxiliary belts placed perpendicularly on the main belts), in order to protect certain land surfaces, mitigate and change the nature of air circulation (wind). Periodical draughts, lack of soil humidity and excessive evaporation are some of the key climate indicators demonstrating the need to establish windbreaks in agriculture. The destructive impacts of wind erosion most strongly affects the arable fields land in flat and mildly wavy areas, with very low or insufficient presence of protective vegetation belts. Establishing windbreaks in agricultural areas is primarily motivated by the following objectives: protection against erosion; creating stable conditions for crops growth and yields; land rehabilitation; increased afforestation of the territory. Additionally, forest windbreaks are an actor of biodiversity renovation and preservation, they act as a physical barrier stopping and binding a major part of pollutants, protecting settlements from noise and pollution, mitigating extreme temperatures. The windbreaks can be particularly significant for beekeeping, if adequate vegetation species are selected. Also, the establishment of so-called „energy“ plantations (ex. *Salix viminalis*, clone Inger) on low-productivity agricultural land (saline, acid, compacted), can produce areas with efficient protection against erosion and significant biomass production intended for energy generation.

The function of windbreaks and the level of their windbreaking effect depends on the aerodynamic features of the windbreak itself: height, width, permeability and distribution. Windbreaks are established in a planned manner, in form of networks aimed at covering a part of the territory and modifying the effects of wind. Depending on the objective, there are three types of windbreaks: impermeable, permeable and evenly distributed.

The impermeable type of windbreaks in terms of its height is characterised by lack of empty space and an even distribution of barriers, starting from crowns and trunks of trees, to bushes in the lower

level (Figure 1). The area of openings is less than 5%, while the wind-permeability between crowns and trunks is less than 30%. The effects are felt at the distance of 20-30 times the height of the windbreak. The wind passes over the upper surface of the windbreak with greater velocity than in the open field, because the currents are reduced die to the reduced surface of the cross-section through which the wind blows. Directly after the belt there is the sheltered zone with no wind. At a certain distance from the windbreak there begins a zone of vortex which, in form of cylinder drops down to the land level which, in winter causes blowing away of snow and, in summer it causes blowing away of fine particles of soil. A series of horizontal vortexes spreads further away from the shelterbelt. In the direction of the air circulation, gains height and loses its strength. In the lower level of the sheltered zone there persists horizontal circulation of very low intensity while at some distance from the belt the vortexes disappear and the field of circulation of the wind again gets the form which it had before hitting the windbreak.

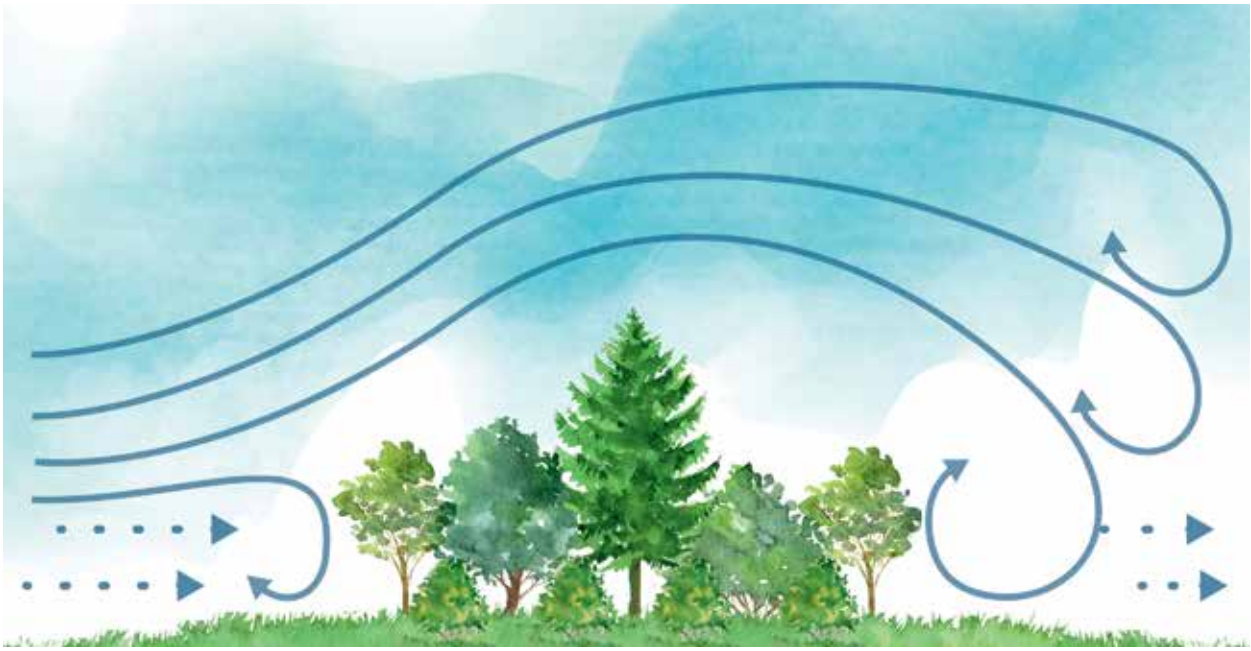


Figure 1. *Impermeable type of windbreak (Authors)*

Permeable type of windbreaks has a full or partial barrier made up of tree crowns in the upper and middle profile, while at the bottom there are openings without bushes (Figure 2). Wind-permeability ranges between 75% between tree trunks and 30% in the crowns. The effects are felt at the distance of 30-40 heights of the belt. A portion of wind currents in the lower layers passes between trees with greater velocity than in the case of evenly distributed belts, so the vortex rejection is stronger, the sheltered zone is longer and the soil protection better.

Figure 2. *Permeable type of windbreak (Authors)*

Evenly distributed type of windbreak is characterised by evenly distributed opening along the whole profile. The wind-permeability between trees is about 30%, and in the crowns between 30-75%. The sheltering effects are felt at the distance of 40-50 heights of the belt (Figure 3). The wind currents are divided into one part which goes above the belt, as in the case of impermeable windbreaks, while the other part passes through the openings in the windbreak („aerodynamic screen"). Horizontal current lines reject the horizontal gale occurring at the closed side, pushing the vortexes to upper heights and not allowing them to get closer to the land surface in the vicinity of the windbreak. This prevents the blowing away of material and significantly increases the sheltered zone of the windbreak.

Figure 3. *Evenly distributed type of windbreak (Authors)*

The areas in which windbreaks are established are usually exposed to impacts of a number of different winds, in terms of their direction, frequency and strength. Thus, auxiliary windbreaks are also needed, which are placed perpendicularly related to the main (primary) belts, creating a net form. Greatest effects of windbreaks are achieved in the sheltered zone which is equivalent to eight times the height of the belt, with positive influence to as many as fifteen heights of the windbreak.

The windbreaks reduce the wind speed and this change the microclimate conditions behind the windbreak.

The air temperature in the lowest layer is **1°C** higher, while the temperature on the land surface is **2°C** higher, the evaporation intensity is reduced by **10-20%**,and the radiation balance is reduced to as much as two times.

When designing windbreaks it is particularly important to plan in detail the types of trees and bushes and their distribution. When establishing windbreaks it is important to select fast growing species capable of quickly forming the full arrangement and achieving the expected effects. Local habitat conditions should be adjusted to the biological requirement soft he planned species, having longevity and biological persistence under the given conditions. When planting, the faster growing species should be placed in the middle of the belt in order not to disturb the slower growing species, and resistant species should be placed along the perimeter of the belt in order to protect the less resistant species, which are planted on the inside of the belt. Local native species are best suited to landscape features, without great functional or esthetic differences.

1.2.

Forest windbreaks in Serbia

According to Article 5 of the current Law on Forests, the term „forest“ has the following meaning:

para 1:

Forest is an area covered with forest trees, of minimum area of 5 acres, and minimum coverage of soil by tree crowns of 30%.

para 3:

Forest means also forest nurseries in forest complexes and seed plantations, as well as protective windbreaks made up of trees of area exceeding 5 acres[1].

The „Regional Spatial Plan of AP Vojvodina until 2020“ (Public Enterprise „Institute for Urban Planning of Vojvodina“, Novi Sad, 2011) it is stated: …“Windbreaks of trees which, if covering an area greater than 5 acres, are considered forests, consist of wind-protective and agri-protective windbreaks, tree avenues, protective greenery along brooks and roads, and smaller areas of unarranged forests of unknown ownership. This greenery does not fulfil its key function – connecting smaller areas under forests with forests of major forest users (Public Enterprise “Vojvodinašume”, Public Enterprise ‘’Vode Vojvodine’’ and the National Park ‘’Fruška gora’’), as well as the protective regulatory function and purpose. Interruptions of contact in forest veg-

[1] Law on Forests, *Official Gazette Of the Republic of Serbia*, No. 30/2010, 93/2012, 89/2015 и 95/2018 – other

etation can impact the bio-eco system which can be exposed to negative environmental impacts"[2]

This strange comment, to say the least, particularly due to the statement that ..."*This greenery does not fulfil its key function – connecting smaller areas under forests with forests of major forest users*" ..., **indicates that there is lack of understanding of the windbreak belts function, which is often reflected in the spatial-urban development plans and the legislation.**

Thus, ... *connecting smaller areas under forests with forests of major forest users* ... is not a key function of forest windbreaks, rather it is the protection or arable land, road and railroad infrastructure, water bodies and canals, against unwanted impacts of wind erosion.

Systems of windbreaks have been established for protection against wind erosion in certain most vulnerable part of the territory of Vojvodina (Table 1). In addition, many design and project documents have been developed for the establishment of protective belt systems which have not been implemented or have been implemented only partially. One of the reason of such poor implementation of protective windbreaks designs is absence of land consolidation (commassation), which was conducted partially or is still lacking. The established windbreaks are located exclusively in state-owned land. Also, the established windbreaks are in some sections not adequately maintained, many of them have lost their density and have the form of low vegetation and bushes.[3]

[2] „Regional Spatial Plan of AP Vojvodina until 2020", Public Institute „Institute for Urbanism of Vojvodina", Novi Sad, 2011.

[3] Pekeč, S., Ivanišević, P., Rončević, S., Kovačević, B., Marković, M., „Plan and program for the establishment of forest belts in Vojvodina", *Topola*, No. 181/182, 2008, UDK: 630*9(497.113), p. 61–70.

Table 1. Surface area of municipalities, forest areas and areas for which windbreaks are designed (Pekeč et al., 2008)

Municipality	Surface area of municipality (ha)	Forest covered surface area of municipality		Surface area of municipality covered by designed windbreaks		Total surface area of municipality under forest	
		(ha)	(%)	(ha)	(%)	(ha)	(%)
Inđija	38600	1414	3.66	259.44	0.67	1673.4	4.3
Srem	**38600**	**1414**	**3.66**	**259.44**	**0.67**	**1673.4**	**4.3**
Kikinda	78200	214	0.27	1831.4	2.34	2045.4	2.6
Ada	22860	409	1.79	672.08	2.94	1081.1	4.7
Kanjiža	39907	919	2.30	655.25	1.64	1574.3	3.9
Zrenjanin	132600	7	0.01	2748.91	2.07	2755.9	2.1
Opovo	20300	1175	5.79	511.48	2.52	1686.5	8.3
Kovačica	41900	8	0.02	568.75	1.36	576.8	1.4
Alibunar	60200	2	0.00	1108.4	1.84	1110.4	1.8
Banat	**395967**	**2734**	**0.69**	**8096.27**	**2.04**	**10830.3**	**2.7**
Subotica	100800	1206	1.20	2062.15	2.05	3268.2	3.2
Vrbas	37600	15	0.04	592.93	1.58	607.9	1.6
Mali Iđoš	18100	44	0.24	382.03	2.11	426.0	2.4
Titel	26200	1655	6.32	800.19	3.05	2455.2	9.4
Temerin	17000	1	0.01	437.37	2.57	438.4	2.6
Žabalj	40000	86	0.22	1002.16	2.51	1088.2	2.7
Bačka	**239700**	**3007**	**1.25**	**5276.83**	**2.2**	**8283.8**	**3.5**
Total	**674267**	**7155**	**1.06**	**13632.54**	**2.02**	**20787.5**	**3.1**

As yet, the Republic of Serbia does not have a registry (cadastre) nor a representative spatial data base of protective windbreaks.

2.

Positions of representatives of relevant institutions on establishment of forest windbreaks

In order to identify the positions of relevant decision-makers and managers, a survey was conducted of employees in public administration and public enterprises. All respondents are technical personnel in the field of forestry, highly educated, with many years of working experience. Their positions are relevant in the process of formulating proposals on planning, financing and managing windbreaks in the Republic of Serbia. The section below summarises the positions of technical personnel from selected institutions, who participated in the anonymous survey. The full version of the interview, in form of 6 questions - 6 answers, is attached in the Annex at the end of the document.

The survey covered a total of
11 representatives
of the following institutions:

- City Administration of Belgrade, the Secretariat of Environmental protection (1 respondent)
- Ministry of the Environment of the Republic of Serbia (1 respondent)
- Forestry Directorate, the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (1 respondent)
- Public Enterprise JP „Srbijašume“ (2 respondents)
- Public Enterprise JP „Vojvodinašume“ (1 respondent)
- Provincial Institute for Nature Protection (4 respondents)
- Provincial Institute for Agriculture, Water Management and Forestry (1 respondent)

Regarding the question
„How should the establishment of windbreaks be organised: based on designs developed by local self-governments or regions or a comprehensive state programme for the whole territory of Serbia?“

the respondents noted the need to develop a comprehensive programme for the whole territory of Serbia, respecting the specific conditions in certain parts of the country and needs of units of local self-government. The concept of windbreaks needs to be integrated in the spatial-planning documentation, followed by elaboration of technical documentation for execution of works.

The question
„Who should manage the existing and future planned forest windbreaks“

led to conflicting responses. Positions were presented that windbreaks should be managed by legal persons having expertise and technical capacities, such as public enterprises „Srbijašume“ and „Vojvodinašume“, water management organisations and companies engaged in road infrastructure, both at national and local level. The answers propose that these should include also major polluters (industrial and energy generating plants, sanitary landfills, etc.) who are obliged to establish protective belts, as well as public utility companies, founded by units of local self-government. On the other hand, respondents insisted that windbreak managers should not be public companies for forest management, but separate organisations founded for this purpose.

Regarding the question
„How do you perceive the role of forest windbreaks in the context of mitigating climate change impacts?“

the respondents stated their positive function through binding carbon, microclimate modification, reducing evaporation, mitigating the effects of urban „heat“ islands, reduced wind erosion, reduced risks of flash floods, protection for road infrastructure from snow drifts.

Regarding the question
„How do you perceive the role of forest windbreaks in renewing biodiversity?“

the respondents noted their relevance as corridors linking habitats and enabling migration of species, but also habitats for preservation and rehabilitation of the living world.

The question
„How can the potential of forest windbreaks be used for establishment of sports and tourism recreational content?“

respondents noted their role as „green“ linear structures along water courses and road infrastructure, with sports-recreational and relaxation contents, equally attractive for the local population and visitors.

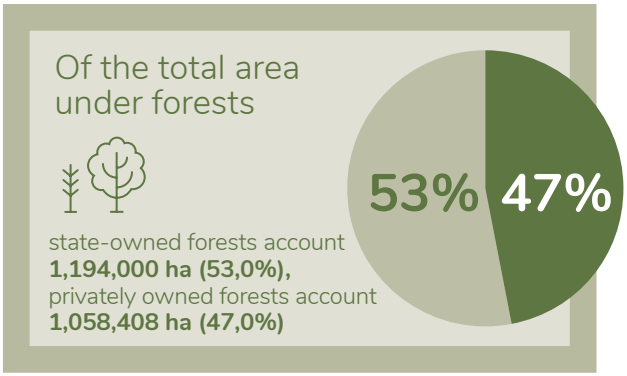
3.

Guidelines for establishment and management of windbreaks

3.1.

Overview of the current state of afforestation (in urban and rural areas) and the state of windbreaks in Serbia

According to data from the National Forests Inventory (last developed in 2008), the total surface area under forests in Serbia is **2,252,400 ha**, equivalent to the level of afforestation of **29.1%** of the total territory[4]. The survey of forests has not been conducted in the territory of the Autonomous Province of Kosovo and Metohija, but an assessment of forest resources was conducted. Forest land, which is not explicitly covered with forest cover, occupies **382,400 ha (4.9%)**. According to this data, the territory of the Republic of Serbia is the least afforested territory relative to other countries of the Balkan Peninsula.



Of the total area under forests, high stands account for **27.5%**, coppice forests account for **64.7%**, and artificially established stands account for **6.1%** while plantations (poplar and willow clones) account for **1.7%** (Figure 4). Old-growth forests cover only **1,200 ha (0.1%)**, semi-natural forests **92.1%** and artificially established stands **7.8%** of the total area under forests. A total of 49 tree species are identified, where broadleaf deciduous species (40), dominate over conifers (9) (Figures 5 and 6). The dominant species in Serbian forests is beech, with the share in total volume of **40.5%**. It is followed by Turkey oak with **13%**, sessile oak with **5.9%**, Hungarian oak with **5.8%**, hornbeam with **4.2%**, black locust with **3.1%**, common oak with **2.5%** and narrow-leaved ash with **1.6%** share in total volume. With respect to conifers, the most frequent is spruce with a share in total volume of **5.2%**, Austrian and Scots pine with **4.5%** and fir

[4] Bankovic, S., Medarević, M., Pantić, D., Petrović, N., *National Forestr Inventorz of the Republic of Serbia – Forest Fund of the Republic of Serbia*, monography, Ministry of Agriculture, Forestry and Water Management, Forest Department, Faculty of Forestry, University of Belgrade, Belgrade, 2008.

with **2.3%**. The share of Euro American poplar clones in the total volume is **1.7%**.

According to data from Statistical Reviews for Forestry (for the period 2014-2017) in the territory of the Republic of Serbia (not including the AP Kosovo and Metohija), there has been a reduction of areas under forests by 3.07%, which is a loss of more than 68,700 ha of forest fund. This loss is the strongest in the areas managed by private forest owners, where the recorded reduction is 4.59% relative to the total area of privately-owned forests, or 58,700 ha. In the same time period, areas under forests which are state owned have reduced by 1.06% (loss of about 10,000 ha). The biggest reduction of area under forests of 5,81% has been detected in territories of statistical regions (level NUTS2) in AP Vojvodina, while the reduced areas in South and East Serbia together amount to 4.16%. it can be concluded that the AP Vojvodina, from its part, is the most vulnerable as this is a region which has been recognised at European level as a spatial unit with the lowest degree of afforestation and the highest loss of forest cover.

The analysis of global data bases (origin: the European Space Agency), established on the basis of remote detection and processing of satellite images for the whole territory of the Republic of Serbia (including also the AP Kosovo and Metohija), identified certain changes with respect to forest areas (Figure 7 and 8)[5]. This analysis confirmed the finding of the greatest loss of forest cover in the territory of AP Vojvodina, in the period 2000 - 2015 (Figure 9 and 12). The reduction of areas under forest (0-5%) is most often a result of urbanisation, and changed purpose of forests and forest land into construction land (in districts Severno Banatski, Severno Bački, Zapadno Bački, Južno Bački, Sremski, Mačvanski and Rasinski). Šumadijski, Toplički and Pčinjski districts have demonstrated a notable increase of area (5-8%) under forest vegetation, due to reduced level of urbanisation and agricultural production, which resulted in spontaneous rehabilitation of forests (Figure 12).

3.1.1. Overview of planned works and expenditures for afforestation in the territory of the Republic of Serbia

The surface area of the Republic of Serbia is

88,361 km²

of which

29,1%

(25,713.05 km²)

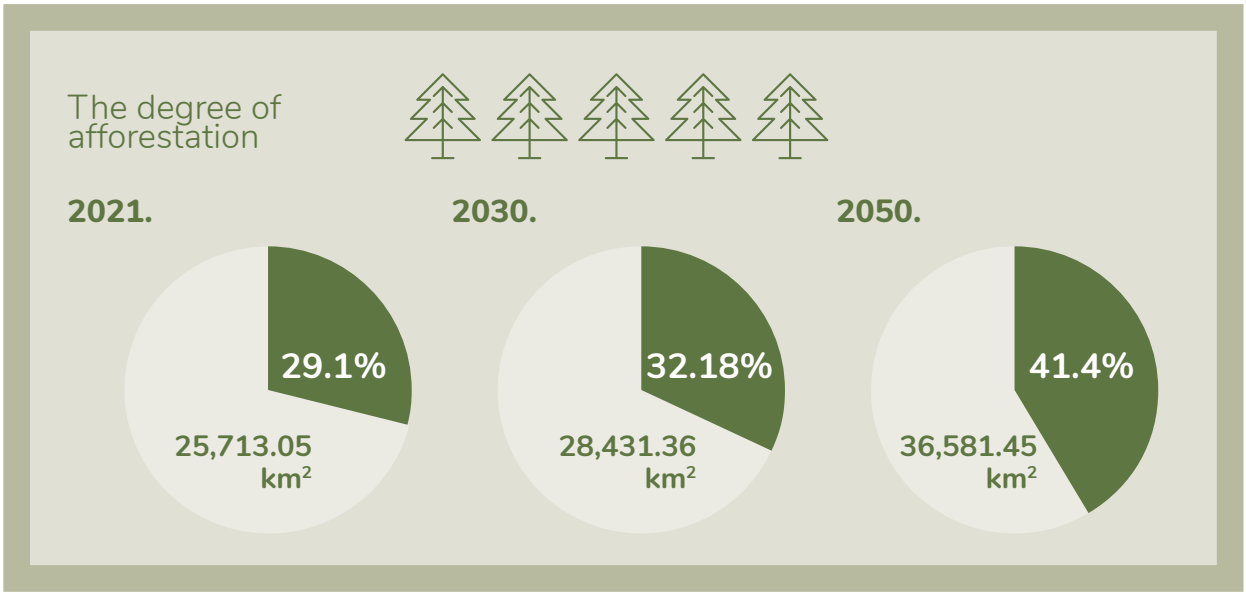
under forest vegetation.

According to the currently prevailing Spatial Plan of RS it is planned that the degree of afforestation by **2050.** should reach **41.4%** (36,581.45 km²), meaning that the surface area under forests would increase by **10,868.40 km²** (1,086,840 ha).

Afforestation of such a great area is a major technical and social challenge which can be addressed through staged performance of relevant activities, in line with appropriated financial, material and technical capacities of Serbia. Therefore, it is proposed in the first stage, in the period 2021 - 2030, according to the United Nations „Sustain-

[5] Global Database, European Space Agency, Paris.

able Development Agenda 2030“, to implement the objectives from the „Strategy of Water Management in the territory of the Republic of Serbia“ and the „Regional Spatial Plan of AP Vojvodina until 2020“, envisaging **afforestation of 100,000 ha** bare land and degraded area south of the Sava and the Danube rivers, as **establishing 171,831 ha** of forests in AP Vojvodina, primarily in form of multi-layered protective windbreaks. Practically, starting with 2021, this would imply annual **afforestation of 27,183.1 ha**, of which 10,000 ha in hilly and mountainous regions south of the Sava and the Danube rivers and 17,183.1 ha in the flatlands of AP Vojvodina, ending with 2030. Taking into consideration that the average costs of afforestation per 1 ha in hilly-mountainous regions is EUR 2,200 (using container seedlings, with planting density of 1,500 seedlings per hectare) and the relevant costs in flatlands in EUR 1,500 the total amount is EUR 477,746,500 or EUR 47,774,650 annually. In the period 2021 – 2030 this would mean **planting 407,746,500 seedlings or 40,774,650 seedlings annually**. Through the implementation of activities of the first stage in the period from 2021 to 2030, the degree of afforestation of Serbia would be increased from 29.1% (25,713.05 km^2) to 32.18% (28,431.36 km^2). Achieving the degree of afforestation of 41.4% (36,581.45 km^2) would require afforestation of additional 815,009 ha in the period from 2031 to 2050, with cost estimates of EUR 1.793 billion.



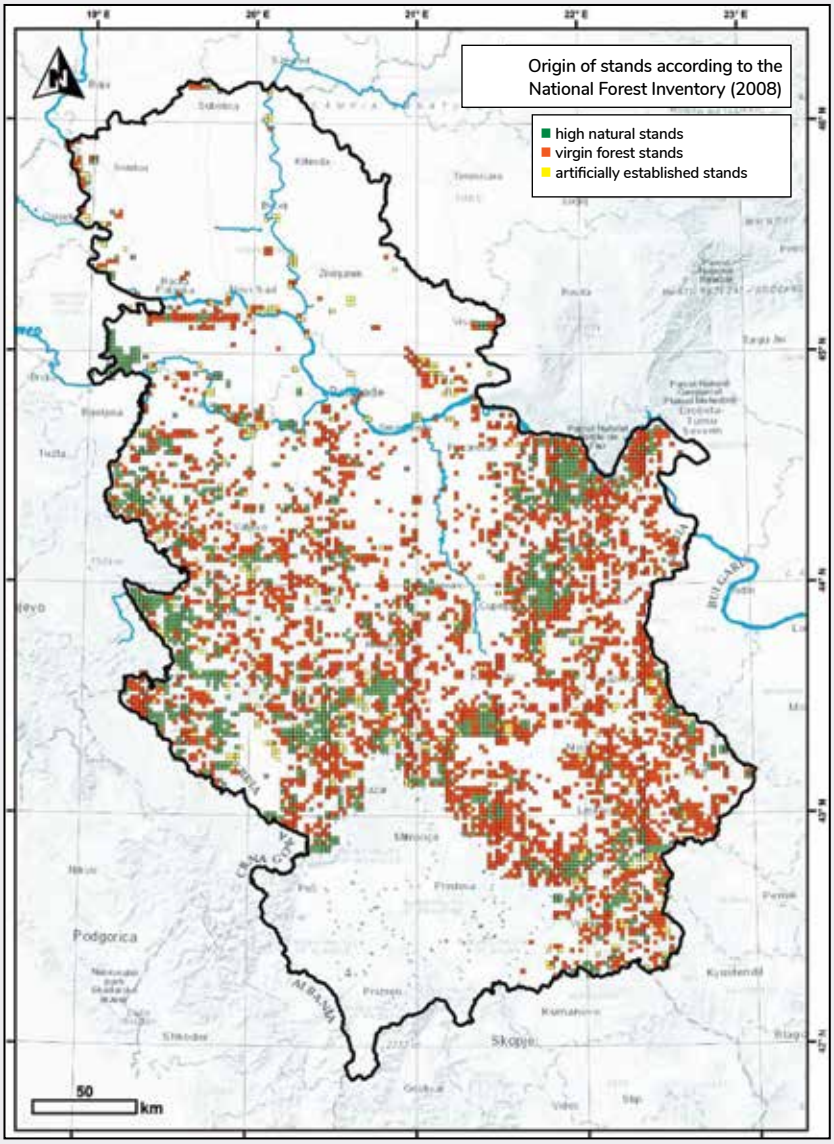


Figure 4. *Origin of stands according to the National Forest Inventory in 2008 (Authors)*

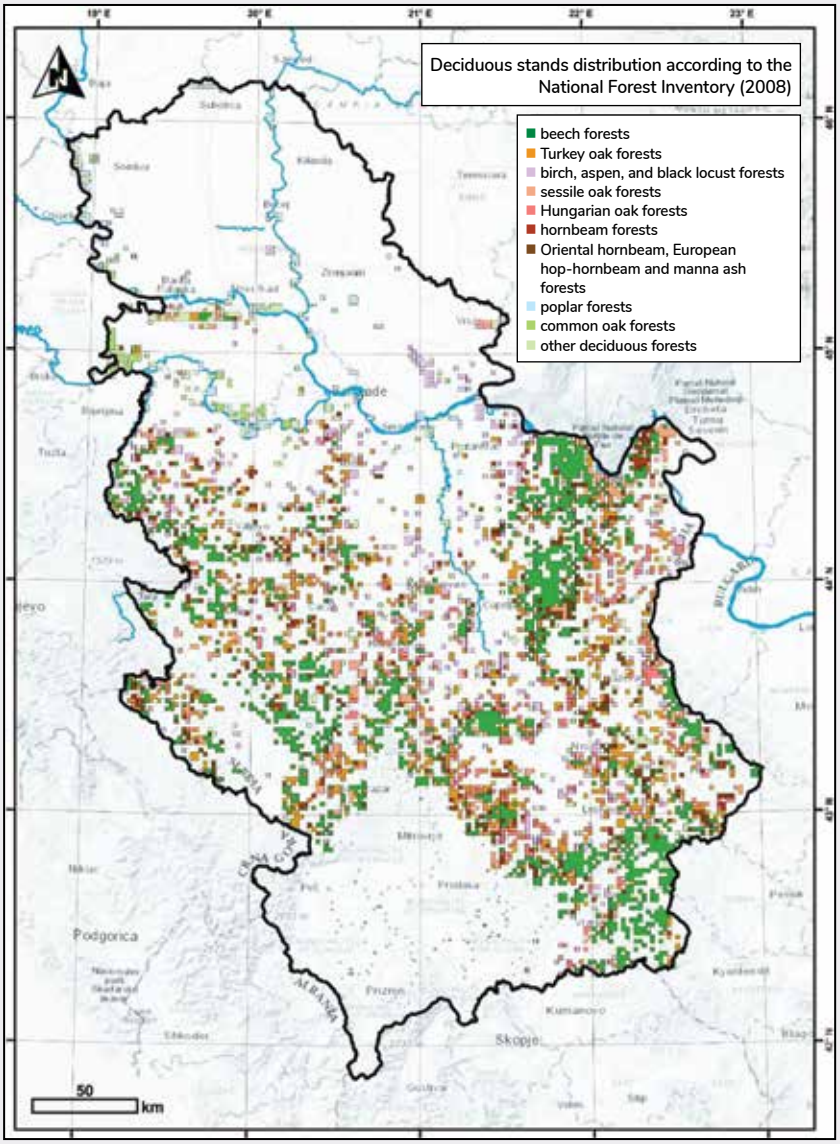


Figure 5. *Deciduous stands distribution according to the National Forest Inventory in 2008 (Authors)*

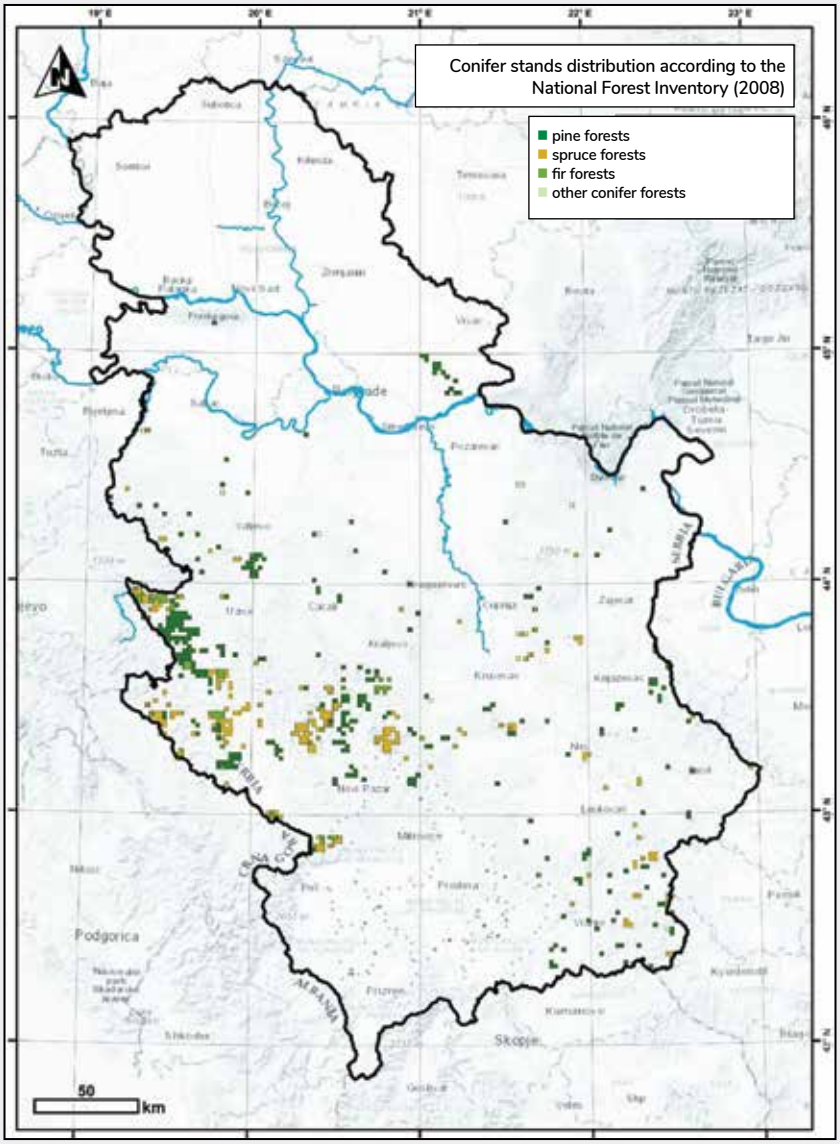


Figure 6. *Conifer stands distribution according to the National Forest Inventory in 2008 (Authors)*

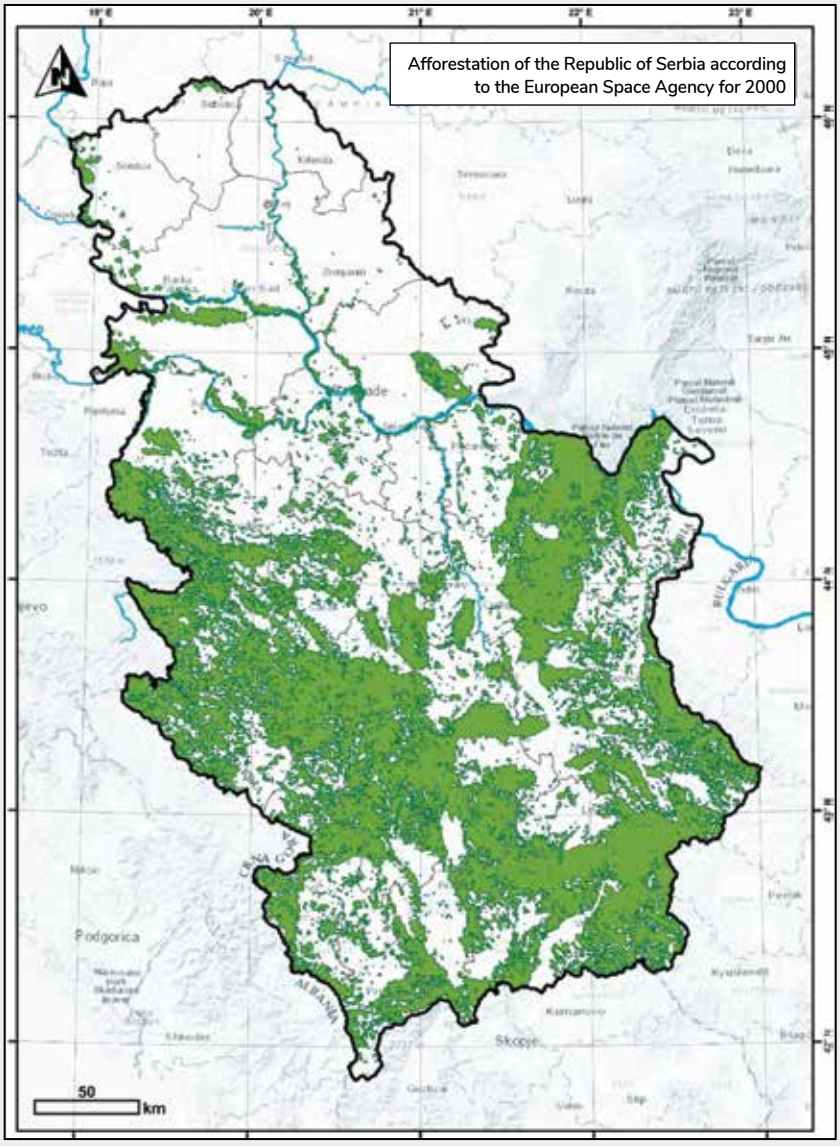


Figure 7. *Afforestation of the Republic of Serbia according to the European Space Agency for 2000 (Authors)*

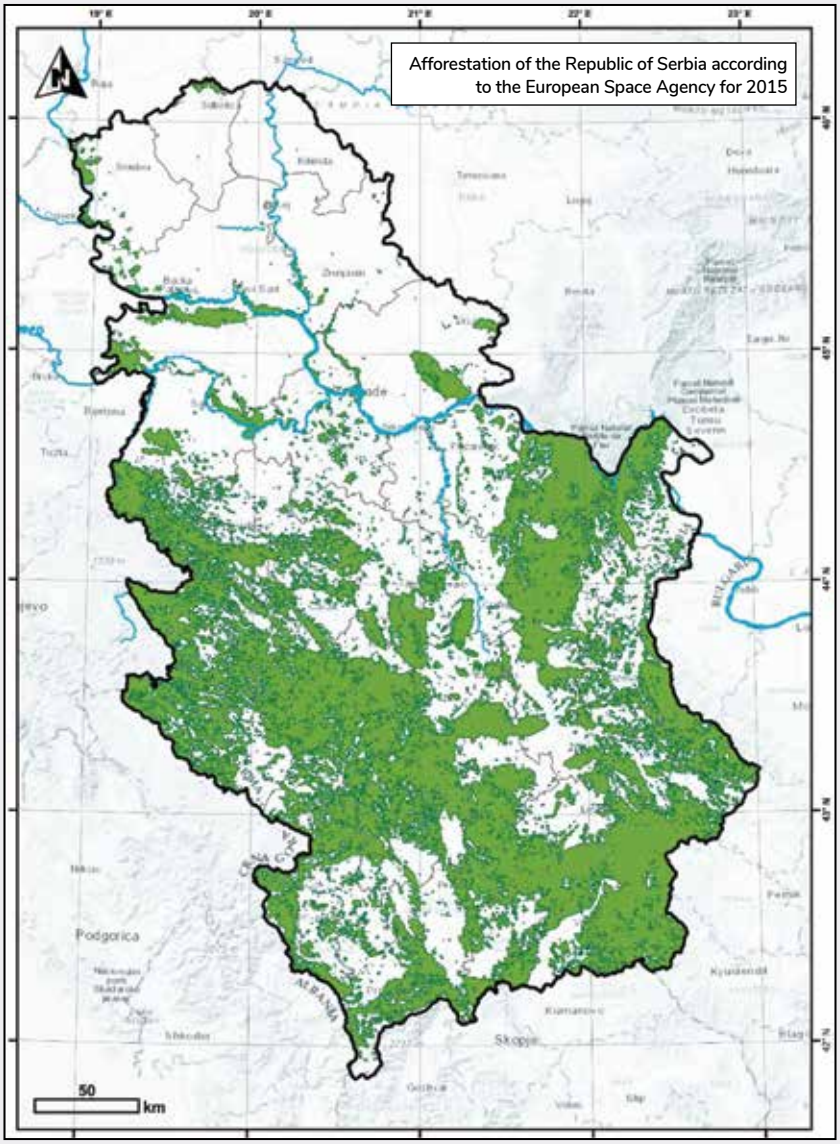


Figure 8. *Afforestation of the Republic of Serbia according to the European Space Agency for 2015 (Authors)*

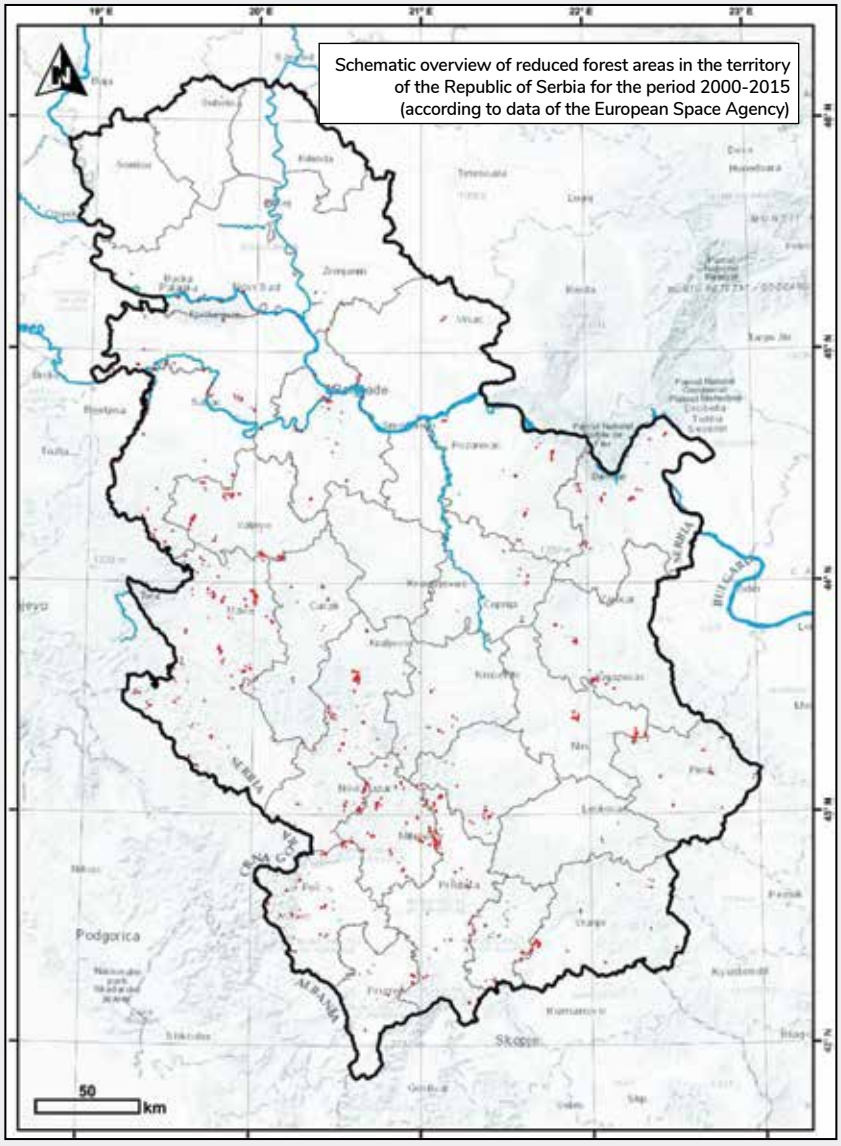


Figure 9. *Schematic overview of reduced forest areas in the territory of the Republic of Serbia for the period 2000-2015 (according to data of the European Space Agency) (Authors)*

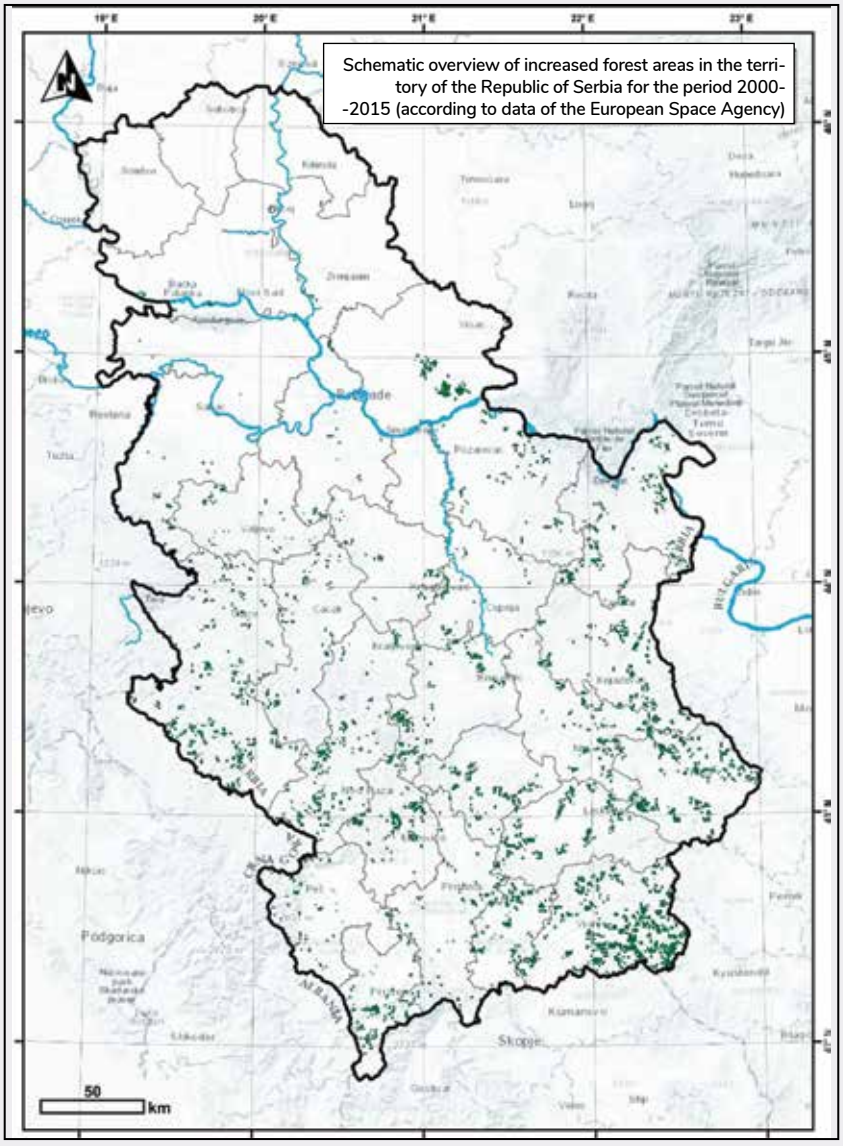


Figure 10. *Schematic overview of increased forest areas in the territory of the Republic of Serbia for the period 2000-2015 (according to data of the European Space Agency) (Authors)*

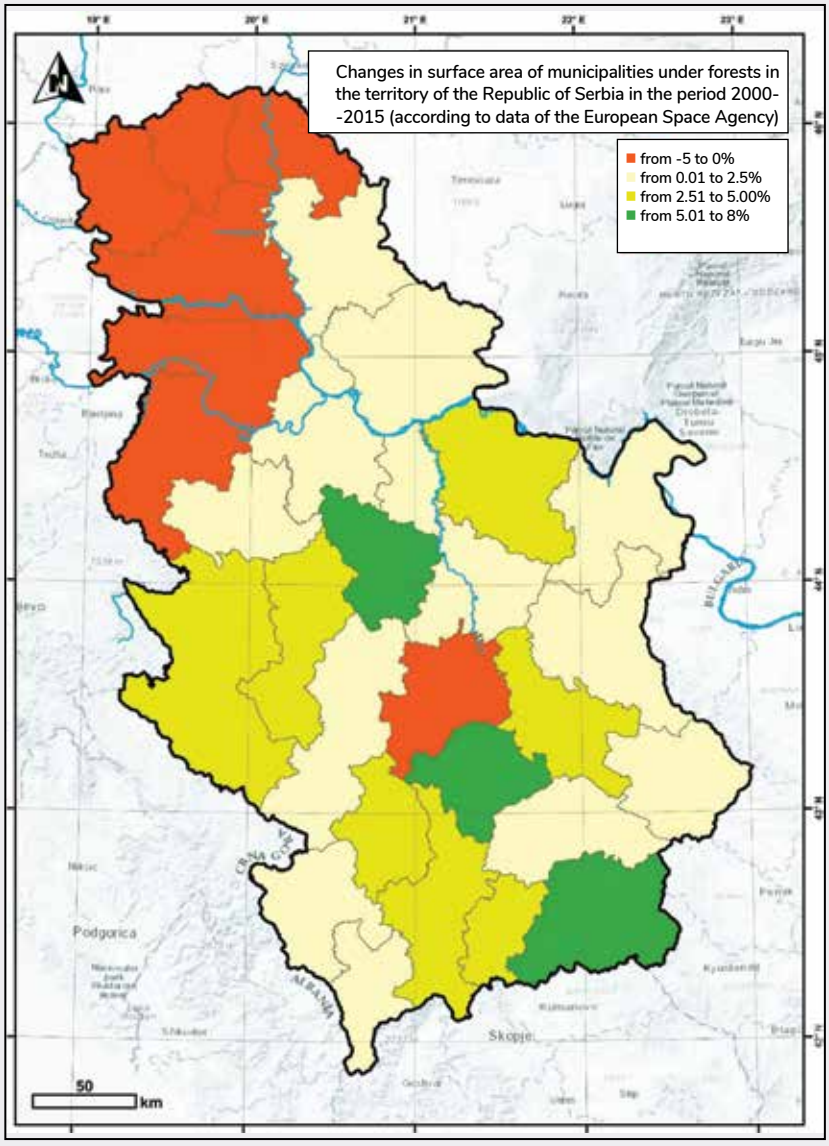


Figure 11. *Changes in surface area of municipalities under forests in the territory of the Republic of Serbia in the period 2000-2015 (according to data of the European Space Agency) (Authors)*

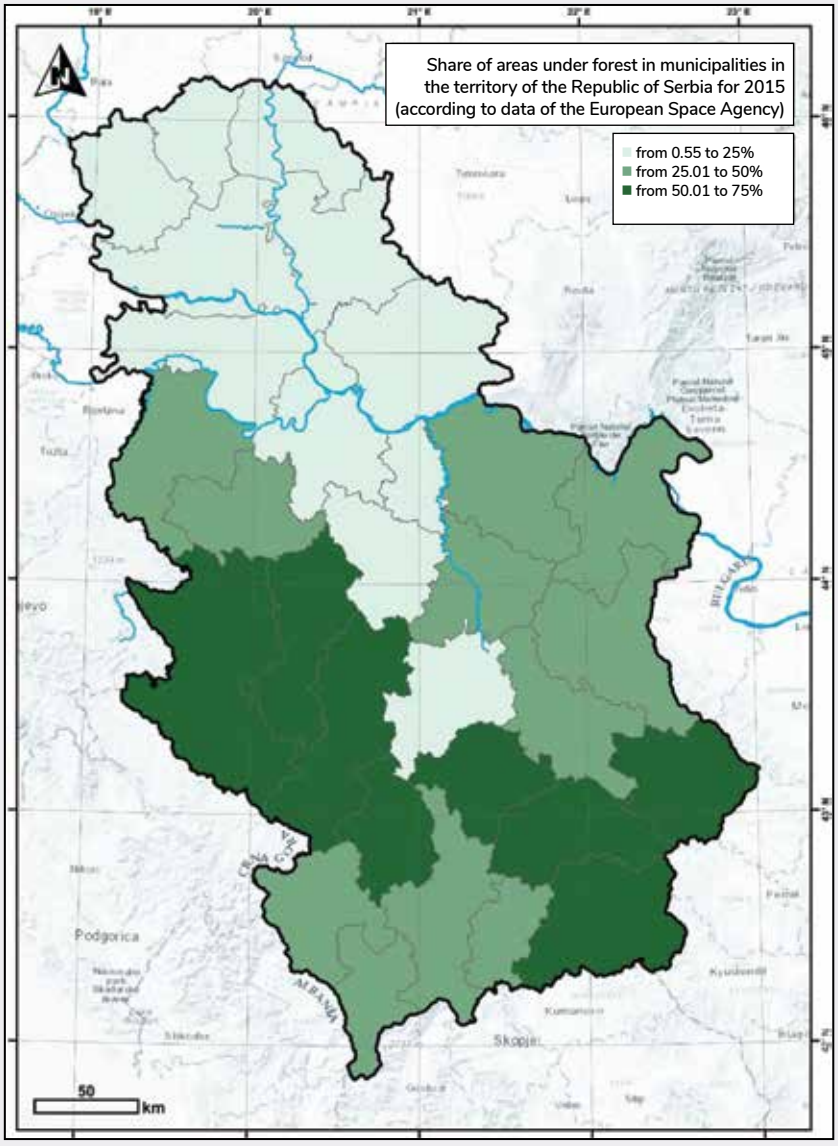


Figure 12. *Share of areas under forest in municipalities in the territory of the Republic of Serbia for 2015 (according to data of the European Space Agency) (Authors)*

3.2.

Analysis of current technical, administrative, managerial, legislative, financial and other challenges for the establishment of windbreaks

The soil degradation process, which is particularly pronounced in agricultural land, requires a serious approach and harmonisation of a number of legislative patterns in order to: reduce the intensity of wind erosion and soil degradation, while increasing fertility and biomass production, as well as the degree of afforestation. The legislation of the Republic of Serbia does not recognise windbreaks as a significant element of the system for protection of soil against erosion and increasing afforestation and the legislation does not attribute to it the adequate relevance. In addition, windbreak belts management requires harmonisation of a number of sectors, such as: forestry, agriculture, water management, road and rail infrastructure, because the establishment of windbreaks contributes to achieving benefits in several interrelated sectors. The text below indicates the laws which partially recognise the issue of forest windbreaks as protective belts, without comprehensively perceiving the complexity of the process, from development of planning and technical documentation, appropriating funds, identifying land suitable for afforestation, appointing custodians/managers, management and maintenance of established belts. Such fragmentation of the issue results in the current practice characterised by poor implementation, often poor quality of performed works, lack of preservation measures and limited soil effects. The failure to utilise the potential for the establishment of windbreaks results in great damages to the sectors of agriculture, forestry, water management, nature protection, tourism, at the same time, it deprives the community as a whole of the benefits of ecosystem services in the domain of mitigating the impacts of climate change, restoration and preservation of biodiversity and a better quality of the environment.

Article 5 of the *Law on Forests* prescribes that forest include, among other things, protective tree windbreaks with surface area greater than 5 acres[6]. Article 8 of this law prescribes that establishing windbreaks in new areas represents establishment of new forests or afforestation. Protective tree and forest windbreaks resulting from afforestation of uncovered areas (Article 70) can be managed by public enterprises or companies founded by the Republic of Serbia, the Autonomous Province, or units of local self-government. Although windbreak belts are recognised as a form of afforestation, achieving protection against wind erosion and protection against landslides for settlements and infrastructure, it is practically not possible to identify clear indicators that would demonstrate some level of systemic implementation of windbreaks.

Planning documents prescribed by the *Law on Forests*, aimed at developing the forestry sector („Strategy of Forestry Development of the Republic of Serbia“, 2006; „Long-term and mid-term business strategy and development plan for 2017-2026, JP „Srbijašume“) do not in any manner address windbreaks as a means to increase afforestation.

[6] Law on Forests, op. cit.

The Law on Agriculture and Rural Development[7] and the „Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024"[8], also do not in any way recognise protective windbreak belts. Although the Strategy perceives erosion as the key challenge to soil quality and states that erosion affects about 25 % of the territory of the Republic of Serbia and mentions anti-erosion measures aimed at soil protection, it does not recognise the role and significance of forest windbreak belts as a contributor to agricultural production.

The Law on Agricultural Land, in its section on protection of agricultural land (Article 18 – Anti-erosion measures), states the establishment and growing of agri-protective belts in order to protect agricultural land against negative impacts of wind erosion (item 6)[9]. The said law in Article 19 states that enforcement of anti-erosion measures is the competence of units of local self-government, which should ensure (item 2) „... that every unit of local self-government the areas susceptible, affected or vulnerable to wind erosion, depending on the specific features of the area and the degree of vulnerability, and in line with the agricultural policy, should develop programmes for protection of land against wind erosion by establishing protective windbreak belts, multi-annual plantations and by implementing other forms of protection, and identifying the time frame for annual implementation of such programmes". Land consolidation (commassation), which is implemented in order to achieve land consolidation and improve natural and environmental land conditions, shall be conducted when anti-erosion works and measures are needed.

The Law on Water perceives vegetation windbreaks as an integral part of flood protection, erosion and flash floods embankments (Article 16, para 2)[10]. Afforestation, growing and maintaining protective vegetation, are just some of the biotechnical and biological protective works and measures mentioned in this law, in order to prevent and remedy negative impacts of erosion and flash floods.

The *Law on Roads*, obliges entities in charge of protecting public roads and traffic on such roads to place protective windbreak belts and other plantations within the road land (Article 87, item 2[11]). The necessary protection, in order to achieve protection of passengers, should be ensured in road sections susceptible to land drifts, flash floods and snow drifts and strong winds.

3.2.1. Limitations and challenges related to establishing windbreaks in Serbia

The process of establishing windbreaks is burdened with numerous challenges and limitations, one of the most prominent being the identification of adequate parcels and spatial corridors, as the initial requirement without which a project cannot be implemented. Achieving windbreak efficiency implies meeting certain requirements related to its length, height, structure, composition, soil type and quality, requiring adequate land space. Since the available space is located along agricultural land, roads (state and municipal), railroads, water management facilities (canals, regulations, embankments), water bodies (water accumulations, lakes, ponds), there is the question of land ownership and competences for management of such space. With respect to privately owned agricultural land, it

[7] The Law on Agriculture and Rural Development, *Official Gazette RS*, No. 41/2009, 10/2013 – other laws, and 101/2016.

[8] Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024, *Official Gazette RS*, No. 85/2014.

[9] Law on Agricultural Land, *Official Gazette RS*, No. 62/2006, 65/2008 – other laws, 41/2009, 112/2015, 80/2017 and 95/2018 – other laws

[10] The Law on Water, *Official Gazette RS*, No. 30/2010, 93/2012, 101/2016, 95/2018 and 95/2018 – other laws

[11] The Law on Roads, *Official Gazette RS*, No. 41/2018 and 95/2018 – other laws

is necessary to acquire permits for change of land use, purchase the land (with adequate compensation) or provide just land exchange, preceded by parcellation, re-parcellation, land consolidation or expropriation. Very often funding is lacking for such activities, and there is lack of willingness of private land owners even in cases when realistic compensation or land exchange is offered.

Many units of local self-government, particularly in the territory of AP Vojvodina, have developed technical documentation (project proposals) for windbreaks, which remains not implemented exactly due to unresolved property issues in the relevant land parcels. One of the key arguments put forward by those rejecting the establishment of windbreaks is that they occupy (lead to loss) of a portion of agricultural land and reduce crop yields, with negative financial consequences. Windbreaks most often occupy 2 – 2.5% of the total arable land, depending on local conditions and terrain morphology (parcel shape, road and canal network density, wind erosion intensity, exposure to pollution).

Practice so far has demonstrated that single-row windbreaks provide very limited effects in terms of protection against wind erosion, and that functionally they are equivalent to tree alleys. The optimum width of windbreaks is 20 to 40 meters, with at least 4 to 6 rows. Although Serbia has never developed a „Cadastre of windbreaks", based on which it would be possible to determine and monitor change, a considerable portion of past windbreaks has in the meantime been significantly degraded or destroyed (according to statements by older colleagues, experts in the field of forestry, agriculture and water management; review of photo-archives, planning and design and technical documents). The motivation includes illegal tree felling for firewood (particularly during the 1990's), as well as removing forest stands in order to increase the arable surface area, and total neglect and negligence. The establishment of windbreaks is a demanding activity, taking at least several years, starting from planning to performance of works and achieving full functionality, and it can all be destroyed in a single day.

3.2.2. The current financial framework for establishment of windbreaks in Serbia

The Decision of the Government of the Republic of Serbia[12] established the Budgetary Fund for Forests of the Republic of Serbia[13], in accordance with Article 81 of the Law on Forests (Official Gazette RS, No. 30/2010). The funding from the National Budgetary Fund is appropriated in accordance with the *Rulebook on requirements and manner of appropriation and use of funds from the annual programme of utilisation of the Budgetary Fund for Forests of the Republic of Serbia and the Autonomous Province*[14]. The funds are appropriated, inter alia, for afforestation, covering a series of activities: afforestation of barren areas; establishment of plantations and intensive plantations; afforestation of barren areas in privately owned forests (distribution of forest seedlings to physical persons); rehabilitation of areas through afforestation; land rehabilitation of degraded forests.

[12] Decision of the Government of the Republic of Serbia, 05 No. 400-9382/2010, as of 23 December 2010

[13] Decision of opening Fund for Forests of the Republic of Serbia, *Official Gazette RS*, No. 100/2010

[14] Rulebook on requirements and manner of appropriation and use of funds from the annual programme of utilisation of the Budgetary Fund for Forests of the Republic of Serbia and the Autonomous Province *Official Gazette RS*, No. 17/2013 and 20/2016

Preliminary results and proposals for contracts under Competitions for award of funds under the annual programme for utilisation of the Budgetary Fund for Forests in 2020 indicate that in the autumn of 2020 appropriations were made in favour of the public enterprise

JP „Srbijašume“, as the biggest beneficiary

- afforestation of barren areas
  80.26 ha in the amount of RSD 10,567,542
- rehabilitation of land through afforestation
  87.70 ha in the amount of RSD 10,614,125
- land rehabilitation of degraded forests:
  115.83 ha in the amount of RSD 16,066,090
- afforestation of privately owned land (distribution of seedlings):
  ha in the amount of RSD 47,250

Land rehabilitation is conducted by spreading forest seeds, planting seedlings of forest deciduous trees or planting container seedlings and cut conifer seedlings on areas resulting from cutting high degraded forests and coppice forests whose present status does not provide for quality high forest stands and optimum land use and protection.

Until the coming into effect of the currently prevailing *Law on Forests* (Official Gazette RS, No. 30/2010-61, 93/2012-28, 89/2015-12, 95/2018-267) the establishment of windbreaks in AP Vojvodina was funded from funds intended for improvement of agricultural land (on the basis of the then valid *Law on Agricultural Land*; „Official Gazette RS“, No. 62/2006, 65/2008 – other laws, 41/2009). Funds were open to all 46 municipalities, according to conditions of public calls. Practically all municipalities also received funds for development of technical documentation (project designs). In the course of 2009 and 2010 funds for establishment of windbreaks were approved to 28 municipalities, at least once during these two years, totalling RSD 46,178,000. Funds were awarded to 8 municipalities, consecutively in 2009 and 2010, totalling RSD 34,097,000. Some municipalities faced difficulties with implementing the contracted projects and justifying the awarded funds. Deadlines under contracts were frequently extended, as a rule at the request of the municipalities, and if the awarded funds were not utilised by the extended deadlines, the funds were to be returned to the budget of the AP Vojvodina. Due to problems related to justifying the utilisation of awarded funds and problems with land (identifying the users and owners; the need to change land use for establishment of windbreaks) annual programmes for award of funds in the period 2011 – 2013 did not include funds for establishment of windbreaks.

Since the coming into effect of the then new *Law on Forests* (2010) windbreaks are considered to be forests and their establishment is funded from the Budgetary Fund for Forests of AP Vojvodina[15]. Since then, the financing of establishment of windbreaks is possible only in accordance with the *Law on Forests*, exclusively on land parcels whose use is defined as forest land and whose owner is determined in accordance with the *Law on Forests*. Table 2 provides an overview, based on available data, of utilisation of funds for establishment of windbreaks, new forests and rehabilitation of degraded forests in the territory of AP Vojvodina in the period 2009 – 2010 and 2014 - 2020.

[15] Decision establishing the Budgetary Fund for Forests of AP Vojvodina, *Official Gazette of AP Vojvodina*, No. 21/2010

Table 2. Overview of funds for afforestation in AP Vojvodina (2009-2020)

	Establishment of windbreaks	
2009.	Approved area for afforestation (ha)	Funds approved (RSD)
	In 22 municipalities	47,275,000.00
Total for 2009	/	47,275,000.00
2010	**Establishment of windbreaks**	
	Approved area for afforestation (ha)	Funds approved (RSD)
	231 (in 14 municipalities)	33,000,000.00
Total for 2010	231	33,000,000.00
	Establishing new forest on state-owned land:	
	Approved area for afforestation (ha)	Funds approved (RSD)
	388.13	48,516,250.00
	Establishing new forest on land owned by physical persons:	
2014	Approved area for afforestation (ha)	Funds approved (RSD)
	8.08	904,500.00
	Establishing new forest on land owned by legal persons:	
	Approved area for afforestation (ha)	Funds approved (RSD)
	12.7	952,500.00
Total for 2014	408,91	50,373,250.00
	Establishing new forest on state-owned land:	
	Approved area for afforestation (ha)	Funds approved (RSD)
	265.42	37,158,800.00
2015	**Establishing new forest on land owned by physical persons:**	
	Approved area for afforestation (ha)	Funds approved (RSD)
	10	1,000,000.00
Total for 2015	275,42	38,158,800.00

2016	**Establishing new forest on state-owned land:**	
	Planned area for afforestation (ha)	Planned funds (RSD)
	337.5	54,000,000.00
	Establishing new forest on land owned by physical persons:	
	Planned area for afforestation (ha)	Planned funds (RSD)
	33	4,000,000
	Establishing new forest on land owned by legal persons:	
	Planned area for afforestation (ha)	Planned funds (RSD)
	32	125,000
	Rehabilitation of degraded forests	
	Planned area for afforestation (ha)	Planned funds (RSD)
	250	25,000,000.00
Planned for 2016	652,5	83,125,000.00
2017	**Afforestation – establishing new forests**	
	Approved area for afforestation (ha)	Funds approved (RSD)
	100.49	13,331,600.00
Total for 2017	100.49	13,331,600.00
2018	**Afforestation – establishing new forests**	
	Approved area for afforestation (ha)	Funds approved (RSD)
	36.82	4,807,600.00
Total for 2018	36.82	4,807,600.00
2019	**Afforestation – establishing new forests**	
	Planned area for afforestation (ha)	Planned funds (RSD)
	/	20,000,000.00
Planned for 2019	/	20,000,000.00
2020	**Afforestation – establishing new forests**	
	Planned area for afforestation (ha)	Planned funds (RSD)
	/	20,000,000.00
Planned for 2020	/	20,000,000.00

In order to increase afforestation of the territory of the Republic of Serbia, the Ministry of Environmental Protection invites public calls for award of funds of the Green Fund of the Republic of Serbia (hereinafter: the Green Fund), in accordance with the requirements prescribed by the *Decree on requirements to be fulfilled by funds beneficiaries, conditions and manner of distribution of funds, the manner of monitoring the utilisation of funds and contract rights and obligations, and other issues relevant to the award and utilisation of funds from the Green Fund of the Republic of Serbia*[16] and the *Rulebook on conditions for award and utilisation of funds of the Green Fund of the Republic of Serbia*[17]. The funds from the Green Fund are awarded for procurement of seedlings and execution of works for afforestation by native tree and bushes species in land owned by units of local self-government (cities and municipalities), as well as city municipalities.

The Ministry of Environmental Protection in the period 2018 – 2020 awarded RSD 152,000,000 for afforestation from the Green Fund. The funds were ear-marked exclusively for units of local self-government in the whole of the Republic of Serbia, of which RSD 106,858,447 (71.24%) (Table 3) was awarded on the basis of adequate technical documentation.

Table 3. The Ministry of Environmental Protection – the Green Fund

	Planned funds in RSD	Awarded funds in RSD
2018	70,000,000.00	40,543,506.61
2019	41,000,000.00	31,087,246.17
2020	41,000,000.00	35,227,694.39

3.2.3. Pre-requirements relevant to the need to establish windbreaks in Serbia

In addition to the above positions and facts, it is of great significance for future activities related to planning, design and performance of works on forest windbreaks, to develop the following documents:

Following documents

Erosion **map** of Serbia

Strategy of prevention and protection against wind erosion

Cadastre of existing forest windbreaks with records of the current state

[16] Decree on requirements to be fulfilled by funds beneficiaries, conditions and manner of distribution of funds, the manner of monitoring the utilisation of funds and contract rights and obligations, and other issues relevant to the award and utilisation of funds from the Green Fund of the Republic of Serbia, *Official Gazette RS*, No. 25/18.

[17] Rulebook on conditions for award and utilisation of funds of the Green Fund of the Republic of Serbia, *Official Gazette RS*, No. 31/18

Additionally, it is necessary to ensure a multi-sectoral approach in considering the problems, preparation of planning and technical documentation, as well as financial documentation, with active involvement of the sectors of agriculture, forestry, water management, transport and railroad infrastructure, energy, environment, management of protected areas, along with the involvement of the local level of government, the public and the civil society.

The implementation of windbreaks should be organised primarily through the Ministry of Agriculture, Forestry and Water Management, and the Ministry of Environmental Protection, with the participation of units of local government. Horizontal coordination should be ensured between the sectors of agriculture, forestry and water management within the ministry in charge. Throughout the process, in addition to other experts (spatial planners, engineers of agriculture, geodetic engineers, landscape and horticulture engineers, engineers of geology, biologists), it is necessary to ensure the involvement of experts of relevant qualification, specifically forestry engineers, licensed for wind erosion protection.

3.3.

Experiences in the process of establishing and maintaining windbreaks

Experts of different profiles have been engaged in addressing the problems of protective windbreaks. The available technical literature offers results of research conducted by scientific institutions, expert practitioners, and a limited scope of data on challenges encountered by custodians and decision-makers.

The experience in designing and maintaining windbreaks have demonstrated that they result in improving all climate, edaphology and biological factors[18], improve soil characteristics and environmental factors, reduce negative impacts of precipitation, waste water and pollutants. They demonstrate particular protective effects against the winds, water and snow[19]. By reducing the wind speed in the areas protected by windbreaks they also change the climatic and edaphic characteristics and initiate favourable biological processes[20]. Windbreaks protect the domestic animals in pasture, not only against wind, but also against high temperatures[21]. At the distance equivalent to five times the height of trees in the windbreak, average air temperatures are lower than in the middle of the field, while at night the effect is the opposite. In fields protected by windbreaks the relative humidity of the air layer directly above the soil is greater than in the open, unsheltered fields. In the sheltered zones of windbreaks the relative air humidity is mostly 5–10% higher, and in extreme cases it can be as much as 38% higher than in the open fields[22]. Additionally, windbreaks reduce evaporation and drying of soil in the sheltered zone. They do not have an effect on volume of precipitation, but they do have an evident impact on retaining a portion of rainfall and snowfall. On the side exposed to wind, the retention is about 17% higher than average[23]. Research has demonstrated that their effectiveness in protec-

[18] Takács, V., Frank, N., "The Traditions, Resources and Potential of Forest Growing and Multipurpose Shelterbelts in Hungary", in: *Agroforestry in Europe, Current Status and Future Prospects*, Springer, 2009, pp. 415–433.

[19] Kachova, V., Hinkov, G., Popov, E., Trichkov, L., Mosquera-Losada, R., "Agroforestry in Bulgaria: history, presence status and prospects", *Agroforestry Systems*, 92, 2018, pp. 655–665.

[20] Takács, V., Frank, N., "The Traditions, Resources and Potential of Forest Growing and Multipurpose Shelterbelts in Hungary", op. cit.

[21] Herzog, F., "The importance of perennial trees for the balance of northern European agricultural landscapes", *Unasylva 200*, vol. 51, 2000, pp. 42–48.

[22] Takács, V., Frank, N., "The Traditions, Resources and Potential of Forest Growing and Multipurpose Shelterbelts in Hungary", op. cit.

[23] *Ibid.*

tion against snowdrifts is greater than in the case of artificial barriers[24]. Comparative studies indicate that efficiently distributed protective windbreaks can contribute to average annual increase of yield of agricultural crops by about 5%[25]. Their role is particularly significant in mitigating key environmental issues attributed to contemporary agriculture, or loss of biodiversity and pollution of groundwater and surface water[26]. Forest windbreaks are an ecotone or a transitory zone between different types of vegetation. Windbreaks are also corridors for movement of birds and insects, linking forests and bushes, enabling exchange of units of populations, preventing isolation and genetic degradation[27]. In coastal areas they contribute to regulating the light regime and water temperature regime in watercourses, acting as a green filter, reducing eutrophication effects, while their roots help stabilise river banks and provide shelter for fish and amphibia[28]. In addition to economic, they also have considerable environmental and landscape value, thanks to landscape modification and enhancement[29]. In order to maximize the effects of windbreaks, it is necessary for them to be of maximum width, thus achieving optimal structure and development, when they produce the best results. Windbreaks efficiency depends on geometrical characteristics (horizontal and vertical), maintenance, the selected species and their distribution. Attention should be paid to their compatibility, regenerative ability and conservation value, as well as use of exclusively domestic and non-invasive species[30].

Different types of windbreaks have been used in Europe for more than 2,000 years. Their oldest form is live hedges made up of trees and thorny bushes, which Julius Cesar described in the *Gallic War* chronicles, as „walls which often provided such strong protection that it was impossible to walk or see through them"[31]. It was only in the 1930's that grandiose projects of windbreaks became a feasible and simple solution for the very complex tasks of preserving the soil and restoring the landscapes of increasingly great dimensions[32].

Thus, after the great sand storms which, during the Depression (1929-1939), raged across the Great Plains in central USA, President Roosevelt asked for (1933) protective belts to be established ranging across parts of the territory of northern and western Texas, western Oklahoma, western Kansas and across central Nebraska[33]. The idea of establishing protective belts was not based on European experiences, but experiences of farmers from Kansas and Nebraska who, by the late 19th century „realised that planting groups or belts of trees prevents wind from blowing away the topsoil"[34]. In fact, the United States Department of Agriculture was working on a minor programme of protective windbreaks ever since 1913. Within this project, until World War Two, 217 million trees

[24] *Ibid.*
[25] Herzog, F., "The importance of perennial trees for the balance of northern European agricultural landscapes", op. cit
[26] *Ibid.*
[27] *Ibid.*
[28] Mosquera-Losada, M.R., McAdam, J.H., Romero-Franco, R., Santiago-Freijanes, J.J., Rigueiro-Rodríguez, A., "Definitions and Components of Agroforestry Practices in Europe", in: *Agroforestry in Europe, Current Status and Future Prospects*, Springer, 2009, pp. 3-19.
[29] *Ibid*
[30] Takács, V., Frank, N., "The Traditions, Resources and Potential of Forest Growing and Multipurpose Shelterbelts in Hungary", op. cit.

[31] Mosquera-Losada, M.R., McAdam, J.H., Romero-Franco, R., Santiago-Freijanes, J.J., Rigueiro-Rodríguez, A., "Definitions and Components of Agroforestry Practices in Europe", op. cit.; Herzog, F., "The importance of perennial trees for the balance of northern European agricultural landscapes", op. cit.
[32] Stein, S., "Coping with the 'World's Biggest Dust Bowl'. Towards a History of China's Forest Shelterbelts, 1950s–Present", *Global Environment* 8, The White Horse Press, 2015, pp. 320–348.
[33] Franklin D., Roosevelt and Conservation, Volume 1, Part II, U.S. General Services Administration and National Park Service, 2009, available on: https://www.nps.gov/parkhistory/online_books/cany/fdr/part2.htm.
[34] Merrill, P.H., *Roosevelt's Forest Army: A History of the Civilian Conservation Corps, 1933–1942*, Montpelier, 1981.

were planted on an area of almost 94,000 ha, thus protecting almost 30,000 farms.[35]

Soviet afforestation projects began in the 1920's reached their peak in 1948 with the „Great Stalin Plan for the Transformation of Nature", the first global attempt to stop climate change induced by anthropogenic factors. The objective was to stop periodical draughts which for decades affected the steppes of southern Russia, by stopping the warm dry winds from Central Asia and thus reducing temperatures and increasing air humidity. Stalin's plan implied the establishment of almost six million hectares of new forests, which is an area greater than all the forests of Western Europe, in form of windbreaks along the rivers in southern Russia and along hedges of agricultural cooperatives[36]. This project by Stalin was abandoned after his death, but it was broadly popularised in Chinese popular science magazines, brochures and books, and so inspired a grandiose afforestation project which the communist Government of the People's Republic of China initiated between 1950 and 1951.

Extreme weather events, known as the „Great North China Drought" (1920–1921) and the „North-West Drought" (1928–1930), took more than ten million lives due to scarcity of food, therefore the new communist government decided to stop the spreading of sand deserts. One of the key instruments in this undertaking was establishing windbreaks, which were presented as the ultimate solution for the rural poverty, migrations and famine[37]. In this manner, during the 1950's, six protective belts were established in different parts of China. The Chinese Ministry of Forestry assessed that **between 1950 – 1957 afforestation covered a total of 129,500 km² of degraded land** which contributed to protection against wind erosion, increased productivity and mitigated the effects of sand storms. One of the last reports about the so-called „Great Green Wall" (1965) stated that the North-Eastern Protective belt was successfully established. After the „Cultural Revolution" (1966-1976), all afforestation projects were abandoned, so in the ensuing period there were no reports about the status of already established belts[38]. Although the Chinese state did truly initiate great afforestation campaigns right after the foundation of the People's Republic of China (PRC), one of the key obstacles was the low degree of seedlings survival, due to inadequate planting, inadequate care and wrong selection of species. According to official assessments by the Ministry of Forestry of the PRC, only about one third of the plantations established since 1949 managed to survive[39].

After the drought and the great famine, which affected the region of Sahel in Africa (in the period

[35] Olson, J.S., *Historical Dictionary of the New Deal: From Inauguration to Preparation for War*, Greenwood Press, Westport, CT, 1985.
[36] Brain, S., "The Great Stalin Plan for the Transformation of Nature", *Environmental History*, 15, 2010, pp. 670–700.
[37] Stein, S., "Coping with the 'World's Biggest Dust Bowl'. Towards a History of China's Forest Shelterbelts, 1950s–Present", *op. cit.*
[38] *Ibid.*
[39] *Ibid.*

1968 - 1973), the disastrous consequences of desertification were recognised globally, culminating in the adoption of the UN **Convention to Combat Desertification** (1977), at the UN Conference in Nairobi. China, as a stakeholder participating at the Conference, only a year later initiated the project of establishing a comprehensive system of protective windbreaks in three regions of North China, most susceptible to erosion. The plan envisaged the establishment of a broad, green protective belt along the so-called „line of sand sedimentation", from the autonomous region Sinkjang, in the northwest, to the province of Heilongjiang in the northeast, within just eight years[40]. The study „Forestry in China"[41] states that this system of protective windbreaks in China is incomparable in its dimensions with anything built in the world so far[42].

Establishment of protective belts in the countries of socialist Europe started intensively in the 1950's.

[40] *Ibid.*

[41] „Forestry in China", *Forestry Magazine*, Food and Agriculture Organization on the United Nations (FAO), 1980.

[42] Stein, S., "Coping with the 'World's Biggest Dust Bowl'. Towards a History of China's Forest Shelterbelts, 1950s–Present", op. cit.

In Hungary, climate conditions and terrain configuration resulted in the term „protective forests“ to first come into use in laws already at the end of the 19th century. The law of 1923 for the first time included provisions related to „afforestation of flatlands“ (it was prescribed to establish shelters, tree alleys and hedges, particularly in agricultural areas greater than 50 ha, and meadows greater than 20 ha)[43]. The Decree by the Council of Ministers (No. 1040/1954) was the first document formulating multi-functional use of forests and identification of environmental „services“ of forest areas. In addition to producing woody biomass, forests were recognised also for other useful functions: protection of farming land, water management, protection against soil degradation, climate modification, health, aesthetic and other functions“[44].

The existing systems of forest protective belts in Hungary were established mostly during the 1960's. 19% of the Hungarian territory was occupied by forests (2000), of which 12.6% (225,862 ha) has a protective function. Forest agri-protective windbreaks occupy 16,416 ha[45].

[43] Takács, V., Frank, N., "The Traditions, Resources and Potential of Forest Growing and Multipurpose Shelterbelts in Hungary", op. cit.
[44] *Ibid.*
[45] *Ibid.*

A more comprehensive use of protective belts started in Bulgaria and Romania at the beginning of 1950's. At that time Bulgaria established a comprehensive network of 9 state-owned forest protective belts. At present, more than 9,000 ha is covered by forest protective belts, most of which are concentrated in the northeast of Bulgaria[46]. The establishment of such protective windbreaks resulted in extraordinary environmental benefits, such as: wind protection (reducing the wind speeds by 30–40%); reducing evapotranspiration by up to 40%; increasing air humidity by up to 16%; reducing daily temperature amplitudes by 3°C in the lower air layers; extending the snow retention period; increasing crops yields by up to 30%; increasing soil humidity by up to 10%; overall improvement of soil fertility protection; crops protection against insects and pests, and settlement of birds within the protective belts[47].

In Romania, this type of protection is cantered mostly in southern parts of the country (the Romanian valley and Dobrogea), which are regions most strongly affected by climate change, and also in farming areas of western and eastern parts of the country. The primary objective of establishing forest protective belts was focused on mitigation of extreme climate events, improving conditions for growing crops, increasing soil fertility and the general level of soil protection[48].

Bulgaria has a number of strategic and other documents and laws regulating and classifying forest protective belts: the *Law on Ownership and Use of Agricultural Land*; the *Law on Forests*; the *Law on Protection of Agricultural Land*; the *Law on Incentives for Agricultural Producers*, etc. The strategic plan for development of the forestry sector (2014–2023) is a document regulating forestry activities, including restoration of old and establishment of new windbreak[49].

After these countries became members of the European Union, efforts were made to harmonise their agricultural and agro-environmental policies with those of the European Union. The Romanian Government promoted the establishment of windbreaks in the vicinity of settlements, alongside roads, on arable surfaces and along irrigation systems. In 2000 the „National plan for agriculture and rural development" was presented, developed by the Regional Development Agency, within the pre-accession programme EU SAPARD, according to which rural communities receive 20% of funding from SAPARD, with emphasis on combatting droughts. The plan stated the objective by 2010 to achieve afforestation of 65,000 ha degraded and abandoned arable land, and establish 2,000 km of protective windbreaks in agricultural land (10% of the SAPARD fund appropriated to Romania). It was estimated that rehabilitation of eroded land will require USD 25-30 billion, over 15-25 years. Planting forest belts on 20,000-30,000 ha and combatting erosion on 1 to 1.5 million ha were planned to be achieved by 2004.

[46] Kachova, V., Hinkov, G., Popov, E., Trichkov, L., Mosquera-Losada, R., "Agroforestry in Bulgaria: history, presence status and prospects", op. cit.; Mihaila, E., Costachescu, C., Danescu, F., Popovici, L., Agroforestry Systems in Romania, 4th European Agroforestry Conference – Agroforestry as Sustainable Land Use, *Conference proceedings*, 2018, pp. 21–25.

[47] Kachova et al., ibid.

[48] Mihaila, E., Costachescu, C., Danescu, F., Popovici, L., Agroforestry Systems in Romania, 4th European Agroforestry Conference – Agroforestry as Sustainable Land Use, op. cit.

[49] Kachova, V., Hinkov, G., Popov, E., Trichkov, L., Mosquera-Losada, R., "Agroforestry in Bulgaria: history, presence status and prospects", op. cit.

The report by the *United Nations Economic Commission for Europe Environmental Performance* of 2000 for Romania includes a recommendation for the Ministry of Agriculture, Food and Forestry in cooperation with the Ministry of Waters and Environmental Protection, to develop afforestation plans for the degraded land and establish windbreaks in agricultural areas[50].

The Government of Romania adopted two laws related to afforestation: the *Law No. 289* (2002) on establishment of windbreaks, and the *Law No. 100* (2010) on afforestation of degraded land. It also adopted the *Resolution No. 547* (2003) on establishing a national system of protective windbreak belts and the draft ''National strategy and action plan to prevent desertification, land degradation, and drought''[51].

For projects to be successfully implemented it is necessary to ensure support and cooperation of private land owners and state organisations when establishing and maintaining windbreaks and ensure a support system through agriculture subsidies[52].

EU countries use economic instruments such as national or international (EU) subsidies and public funds, as well as compensation payments for support to different forest protection services. For example, Bulgaria and Ukraine provided state support for the establishment of windbreaks in eroded land, or planting protective forests. Croatia collected the so-called „green taxes" to finance measures ensuring protective functions of forests, and Montenegro and Romania financed compensations, from national funds, to forest owners in order to cover reduced revenues from wood exploitation in protected or protective forests[53].

According to the *Law on Establishing Windbreaks* of the Republic of Romania, 2002, protective windbreaks can be public or private property and they are assets of national interest (Article 3)[54]. The national system of windbreaks is declared to be a national asset and is under the jurisdiction of the authorities in charge of forestry (Article 4). Studies for the establishment of windbreaks are developed by forestry research institutes, whose services are financed through public procurement. The developed studies are reviewed by the Academy of Agriculture and Forestry Sciences "Gheorghe Ionescu-Sisesti". Technical-economic documentation for the establishment of forest windbreaks is developed by licensed legal persons, whose services are funded through the system of public procurements. Protective windbreak belts are developed based on detailed technical-economic documentation (project designs), covering all the necessary elements: location, width distance between windbreaks; planting schemes; specification of species; measures of care; specification of costs; identification of owners. Review and verification of technical-economic documentation for the establishment of forest windbreaks is conducted by the highest national authorities in the field of forestry (Article 7).

[50] Economic Commission for Europe, Committee on Environmental Policy, Environmental Performance Reviews, Romania, UN, New York, Geneva, 2001.

[51] Ibid.

[52] Takács, V., Frank, N., "The Traditions, Resources and Potential of Forest Growing and Multipurpose Shelterbelts in Hungary", op. cit.

[53] State of Europe's Forests, Status and Trends in Sustainable Forest Management in Europe, United Nations, UNECE, FAO, 2011, available at: https://www.unece.org/fileadmin/DAM/publications/timber/Forest_Europe_report_2011_web.pdf.

[54] Law on the Establishment of Protective Belts of the Republic of Romania, 2002, available at: http://www.clr.ro/rep_htm/L289_2002.htm.

Land owners are obliged to report on implementation of the „National system of forest protective windbreaks“ through specialised state forestry organisations by publishing reports on websites of such institutions. If land owners do not provide a permit for the execution of works, the expropriation process is initiated in order to achieve the public interest. The expropriating entity is the state of Romania, through the National Forestry Directorate (Article 9). The final commissioning of works for implementation of the „ National system of forest protective windbreaks“ is conducted with the mandatory involvement of land owners, representative of the state forestry service and expert organisations for execution of works (Article 11).

Owners of forest windbreaks are obliged to undertake fire prevention and control measures, comply with the provisions on forest protection and trade in wood materials and implement maintenance measures, as prescribed by technical norms and regulations. In conducting these activities they are supported by state forestry authorities, local governments (prefectures, district and local councils), police, gendarmeries and firefighting units, and the Ministry of National Defence. At the request of protective windbreaks owners the State Forestry Directorate, through its territorial units, undertakes safeguarding and management of relevant forest vegetation, based on contracts and agreements signed with applicants (Article 25). The area under protective windbreak belts must not be reduced, irrespective of the ownership scheme (Article 26). Collection of wood material from the area under protective windbreaks is allowed only with the prior transfer, with compensation, except in cases of wood material of diameter less than 10 cm, which is collected and taken away under the supervision of technical forestry staff, without prior marking (Article 28). The control of enforcement of forestry rules and rules applicable to safeguarding forest vegetation in windbreaks, as well as regulations applicable to trading in wood materials, is conducted by a public body in charge of forestry, through the commissioners for forestry and hunting in their areas of jurisdiction (Article 29).

Developing studies, technical and financial documentation related to windbreaks and the execution of relevant works is funded from the following sources:

- the fund for preservation and regeneration of forests;
- the environmental protection funds;
- municipal, city and district budgets;
- corporate sponsorship;
- grants provided by external financial sources or long-term foreign loans;
- and contributions by physical and legal persons.

The central state administration authority in charge of forestry, as the technical coordinator of activities for project implementation within the „National system of forest protective windbreaks“, every year defines the budget appropriation item stating the amount of funding necessary for afforestation in the coming year.

Financing staff for administrative tasks, protection against looting and prevention of illicit pasturing, is ensured from the state budget, by funding the central authority in charge of forestry (Article 31). The central state authority in charge of forestry, together with other ministries with interest in the development of windbreaks, every year by 30 May submits the report stating the financial status for implementation of the „National system of forest protective windbreaks", for the subsequent year. Approved funding is deposited in bank accounts, with relevant interest, and is utilised in the forthcoming fiscal year, independently of appropriations from the national budget (Article 33). The central authority in charge of forestry every year appropriates the necessary funds for establishment of forestry belts for the protection of agricultural land, prevention and combatting of drought and desertification (Article 34).

Programmes for implementation from the „National system of forest protective windbreaks" are harmonised by the central national authority in charge of forestry in cooperation with the Ministry of Agriculture and Rural Development, the Ministry of Public Administration and the Interior, the Ministry of Transport and Infrastructure, the academy "Gheorghe Ionescu-Sisesti" (for agricultural and forestry sciences), and other stakeholder institutions and economic operators. In case of expropriation, the central national authority in charge of forestry is competent to ensure annual updating of the central registry of public state property (Article 37).

In districts in which the network of windbreaks is established, district commissions are established under the direct supervision by the head of district, consisting of district directorates for agriculture, forestry and other stakeholder institutions. Mayors periodically review the stages of implementation of annual programmes for the establishment of forest windbreaks at local level, or district level (Article 38). The central national authority in charge of forestry reports annually to the Government on the inventory of land appropriate for inclusion in the „National system of forest protective windbreaks" (Article 41). Owners of land in which windbreaks are located do not pay taxes and other fees prescribed by the law (Article 42), but are obliged after the establishment of windbreaks to maintain and protect the forest vegetation, in compliance with technical norms for this category (Article 43)[55].

According to the national budget of the Republic of Romania for the year 2017, the Ministry of the Environment received ROL (Romanian leu) 471 million (EUR 97.11 million), or 0.057% of the GDP (ROL 73 million, or EUR 15.05 million more than the budget for 2016). One of the key objectives of such a budget (in addition to providing equipment and raising awareness on selective waste collection, and the programme Green House) is afforestation and development of forest protective windbreaks. According to the same budget, the Ministry of Waters and Forestry receives ROL 347 million (EUR 71.55 million), or 0.042% of the GDP (ROL 95 million, or EUR 19.59 more than in the preceding year), and the key objectives and afforestation of at least 5,000 ha, arrangement of flash flood rivers by consolidating river banks, and the programme ''cut one tree and plant two!''[56].

[55] Ibid.
[56] Internet, available at: https://gov.ro/en/government/cabinet-meeting/the-budget-for-2017-approved-by-the-government.

3.4.

Recommendations for improvement of the existing technical, administrative, managerial, legislative, and financial framework for successful establishment and maintenance of protective windbreaks in units of local self-government, including an innovative model for the establishment of windbreaks applicable to Serbia

General requirements for the establishment of forest windbreaks are based on the existing legislation and strategic directions from the current spatial planning documents. The issue of windbreaks is also compatible with the activities for implementation of the „RIO“ conventions (UNFCCC, UNCCD, UNCBD), „The Sustainable development Agenda 2030“, the Sustainable Development Goals, particularly goal 15 („Life on Land“), and the adopted LDN-Land Degradation Neutrality document (2019).

The issue of protective windbreaks is addressed in the following key laws of the Republic of Serbia:

- Law on Forests ("*Official Gazette RS*", No. 30/2010, 93/2012, 89/2015 and 95/2018 - other laws), articles 5, 8 and 70
- Law on Agricultural Land ("*Official Gazette RS*", No. 62/2006, 65/2008 - other laws, 41/2009, 112/2015, 80/2017 and 95/2018 - other laws), articles 18 and 19
- Law on Waters ("*Official Gazette RS*", No. 30/2010, 93/2012, 101/2016, 95/2018 and 95/2018 - other laws), article 16
- Law on Roads ("*Official Gazette RS*", No. 41/2018 and 95/2018 - other laws), article 87

A significant support to the efforts for establishment of windbreaks is the need to increase afforestation of the Republic of Serbia. According to the currently prevailing „Spatial Plan of the Republic of Serbia from 2010 to 2020“ (PPRS 2010-2020), it is envisaged to increase the level of afforestation to 41.4% by 2050[57]. Therefore, **the share of forests needs to be increased from the current 25,713.05 km^2 to the planned 36,581.45 km^2, or to establish new forests on 10,868.40 km^2 (1,086,840 ha)**.

[57] Law on the Spatial Plan of the Republic of Serbia from 2010 to 2020, *Official Gazette RS*, No. 88, 2010, Ministry of Environmental Protection and Spatial Planning, Republic Agency for Spatial Planning, Belgrade, 2010.

At the same time, according to the „Regional Spatial Plan of the AP Vojvodina“ (RPPAPV)[58] (Provincial Secretariat for Urban Planning, Construction and Environment of AP Vojvodina, 2011) it is envisaged to increase the area under forests in AP Vojvodina to 14.3%, from the current 6.7% (RPPAPV, p. 25), or 6.37% (according to data of the public enterprise JP „Vojvodinašume“[59].

Protective windbreaks are needed in order to achieve the following objectives: protection of arable land against wind erosion; protection of the DTD canal system from wind-caused sedimentation; protection of the road and railroad infrastructure against snow drifts; protection of settlements against pollutants during windy episodes; visual isolation of municipal waste landfills and disposal sites; protection of water surfaces (lakes, ponds); establishing corridors for biodiversity rehabilitation and protection; establishing sports-recreational infrastructure within the windbreak systems (cycling and trim tracks, open exercise grounds, resting sites, educational tracks, children playgrounds, contents for persons with disabilities; linking urban green infrastructure with the existing and future windbreak belts; networking such belts into a system of „blue-green“ and environmental corridors); protection of settlements against noise and pollution. Such multi-functionality requires a planning/management centre at the national level of Serbia, with broad competences for establishment and maintenance of the windbreak belts system. Certain competences are to be delegated to units of local self-government in terms of preparation of technical documents, in line with the nationally adopted general concept for establishment of windbreak belts, with tailored solutions reflecting local specific features (relief, microclimate conditions, and specific requirements).

[58] Regional Spatial Plan of the AP Vojvodina , Provincial Secretariat for Urban Planning, Construction and Environment of AP Vojvodina, Novi Sad, 2011

[59] Internet, available at: http://www.vojvodinasume.rs/sume/procena-optimalne-sumovitosti-u-vojvodini/.

3.5.

Guidelines for units of local self-government in the process of developing technical documentation for the establishment of windbreak belts

3.5.1. Identification of the erosion potential of locations, particularly the intensity of wind erosion

Wind erosion is a serious environmental threat as a physical process[60] causing significant land degradation in arid, semi-arid and agricultural areas[61]. This includes loss of the finest and biologically most active topsoil, rich in organic matter and nutrients[62]. Transport of soil particles begins when the kinetic energy of wind overcomes the gravity and cohesive forces on the land surface which is mostly without vegetation[63]. Areas susceptible to wind erosion have certain characteristics in common, primarily the climate with pronounced dry periods and frequent winds throughout the year. In addition, areas prone to wind erosion include loose soils. Most often sandy soils, flatland relief and deforested areas with intensive agriculture. Such negative fac-

[60] Lal, R., “Soil erosion by wind and water: Problems and prospects”, *Soil Eros. Res. Methods*, 2, 1994, pp. 1–9.

[61] Borrelli, P., Panagos, P., Montanarella, L., “New Insights into the Geography and Modelling of Wind Erosion in the European Agricultural Land. Application of a Spatially Explicit Indicator of Land Susceptibility to Wind Erosion”, *Sustainability*, 7, 2015, pp. 8823–8836.

[62] Funk, R., Reuter, H.I., “Wind erosion”, in: Soil Erosion in Europe, Boardman, J., Poesen, J. (eds), Wiley, Chichester, UK, 2006, pp. 563–582.

[63] Shao, Y., *Physics and Modelling of Wind Erosion*, Springer, Cologne, Germany, 2008.

tors can lead to the ultimate stadiums of wind erosion effects, which is desertification. This process is global, and is particularly intensive in the direct or broader regions around the Equator, and also in part of the northern and southern hemisphere.

According to certain research, it is estimated that within the next ten years desertification will threaten and force migrations of almost 50 million people.

Desertification and soil degradation are significantly accelerated due to the increasing anthropogenic pressures on primary natural resources (soil, forests, water)[64].

In Serbia, particularly in the region of Vojvodina, much research has been done including soil loss calculations, due to wind erosion effects. According to Velašević, the most susceptible regions in Serbia are Vojvodina, particularly its western part, the valley of the river Morava and the city of Vranje with its vicinity (Figure 13), which was determined based on the index of susceptibility to wind and drought.[65]

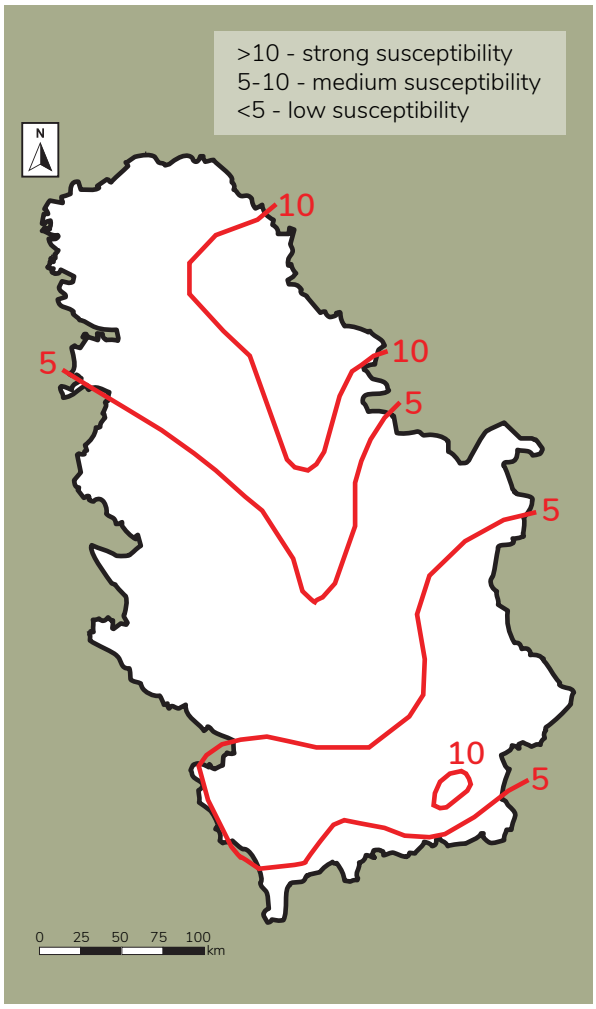


Figure 13. *Index of susceptibility to wind and drought, according to Velašević (Velašević, 1970)*

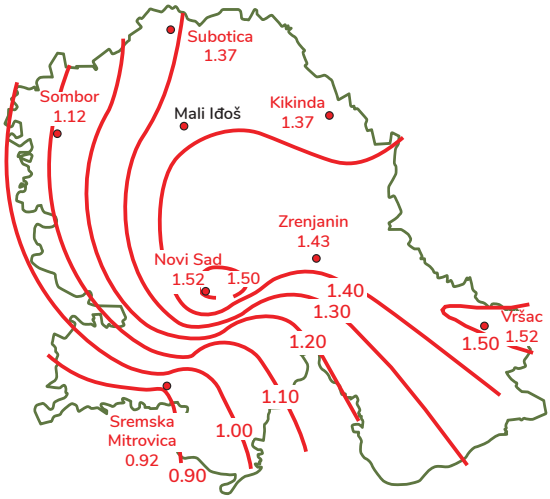
According to the Pasak method (Pasak, 1967), with respect to the value of wind erosion intensity, the region of Vojvodina is classified among compromised soils, with wind erosion intensity of 0.9-2.0 t/ha annually (the quantity of soil blown off)[66].

[64] Ristić, R., Radić, B., Polovina, S., Ристић Р., Радић Б., Половина С., *Report on the applied methodology and identification of objectives for establishing neutrality of land degradation in the Republic of Serbia*, Ministry of Environmental Protection, Belgrade, 2019.

[65] Velašević, V., *Land zoning of FR Serbia in order to raise forest field protection belts, doctoral dissertation*, Faculty of Forestry, Belgrade, 1970.

[66] Pasak, *Faktory ovlivnujci vetrnov vetrnouerozi pudy*, Vedecke prace, VUM, Praha, 1967.

Figure 14 presents the spatial distribution of effects of wind erosion, with greatest intensities around Vršac, Zrenjanin, and Novi Sad. In the category of strongly disturbed land (I category) there is 2.08% of the total area of AP Vojvodina, with intensity exceeding 2.0 t/ha annually. The category of disturbed land (II category), with intensity from 0.9 to 2.0 t/ha annually covers 84.35% land surfaces. The category of minor disturbed land (III category) occupies 7.20%, with intensity ranging between 0.3 and 0.9 t/ha annually. Wind erosion intensity less than 0.3 t/ha annually (IV category) exists in 6.37% of the region.



I category:
Highly disturbed land – above 2.0 t/ha annually

II category:
Disturbed land – from 0.9 to 2.0 t/ha annually

III category:
Mildly disturbed land – from 0.3 to 0.9 t/ha annually

IV category:
Very mildly disturbed land – below 0.3 t/ha annually

Figure 14. *Wind erosion intensity in the territory of Vojvodina, based on Pasak method (Pasak, 1967)*

Wind erosion intensity depends on numerous factors, including: climate, vegetation, soil characteristics, impact of anthropogenic factors, etc. The author Radovan Savić presented, on the basis of the climate factor, the spatial and temporal distribution of potential land susceptibility to wind erosion in the territory of Vojvodina[67]. The climate factor is the index of non-dimensional value, which qualifies the risk and enables presentation of areas with potential for wind erosion. According to the existing meteorological stations, Figure 15 presents the isohypses and maximum values of the climatic factor of wind erosion. The potentially most susceptible regions are in Banat, where the climate factor is 3 to 4 times higher relative to other parts of AP Vojvodina[68].

[67] Savić, R., Letić, L., Benka, P., Ondrašek, G., Nikolić, V., „Prostorna i vremenska raspodela potencijalne ugroženosti područja Vojvodine procesima eolske erozije“, Agroznanje, vol. 13, br. 2, 2012, стр. 191–198.

[68] *Ibid.*

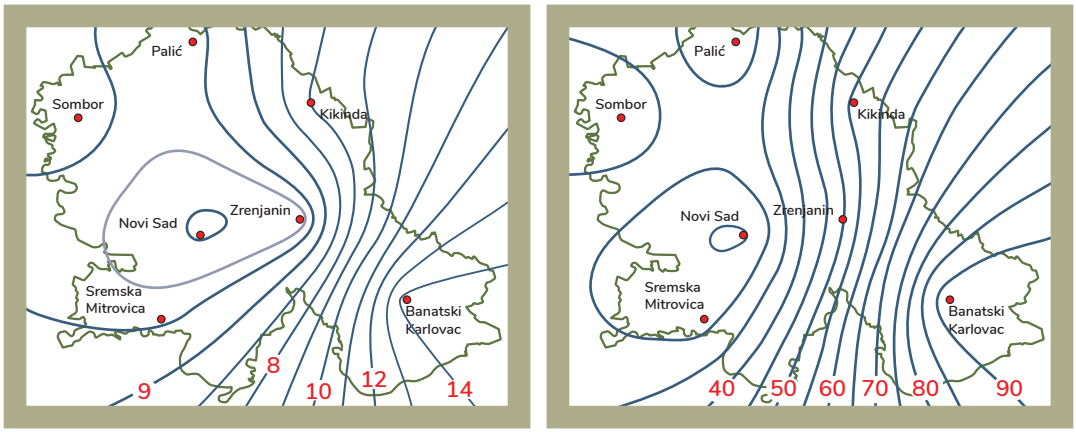


Figure 15. *Isohypses of average and maximum monthly values of wind erosion factors (Savić et al., 2012)*

Wind erosion is a great threat and cause of damages, both in the Republic of Serbia and in other parts of Europe, such as the north of Germany, east Netherlands, east UK and the Pyrenean peninsula[69]. Most recent research and studies assessing the wind erosion intensity in the European continent were conducted only with respect to EU member states[70], while one of them took into consideration also the Republic of Serbia[71]. Such research identified susceptible and potentially susceptible regions to impacts of wind erosion on agricultural land[72]. For the purposes of the analysis, the research used the index of land susceptibility to wind erosion – ILSWE, applied in the GIS context. Figure 16 presents the spatial distribution of the susceptibility index (ILSWE) for the Republic of Serbia. According to the categories used, agricultural land susceptible to wind erosion (moderate to high susceptibility) occupies 0.3 million ha, or 19.9% of the total agricultural area[73]. According to the map, the greatest susceptibility is in part of central and southern Banat, and the Braničevo district.

[69] Eppink, L.A.A.J., Spaan, W.P., "Agricultural wind erosion control measures in The Netherlands", *Soil Technol.* Ser. 1, 1989, pp. 1–13; López, M.V., Sabre, M., Gracia, R., Arrue, J.L., Gomes, L., "Tillage effects on soil surface conditions and dust emission by wind erosion in semiarid Aragon (NE Spain)", *Soil Tillage Res.*, 45, 1998, pp. 91–105; Bärring, L., Jönsson, P., Mattsson, J.O., Åhman, R., "Wind erosion on arable land in Scania, Sweden and the relation to the wind climate", A review, *Catena*, 2003, pp. 52, 173–190; Warren, A., *Wind Erosion on Agricultural Land in Europe: Research Results for Land Managers, Office for Official Publications of the European Communities*, Bruxelles, Belgium, 2003; Martínez-Graña, A.M., Goy, J.L., Zazo, C., "Water and Wind Erosion Risk in Natural Parks–A Case Study in "Las Batuecas-Sierra de Francia" and "Quilamas" Protected Parks (Central System, Spain)", *Int. J. Environ. Res.*, 8, 2014, pp. 61–68.

[70] Borrelli P., Ballabio C., Panagos P., Montanarella L., "Wind erosion susceptibility of European soils", *Geoderma*, 2014, pp. 232–234, 471–478; Borrelli P., Lugato E., Montanarella L., Panagos P., "A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach", *Land Degradation & Development*, 28, pp. 335–344, DOI: 10.1002/ldr.2588, 2017.

[71] Borrelli, P., Panagos, P., Montanarella, L., "New Insights into the Geography and Modelling of Wind Erosion in the European Agricultural Land. Application of a Spatially Explicit Indicator of Land Susceptibility to Wind Erosion", op. cit.

[72] Ibid.

[73] Ibid.

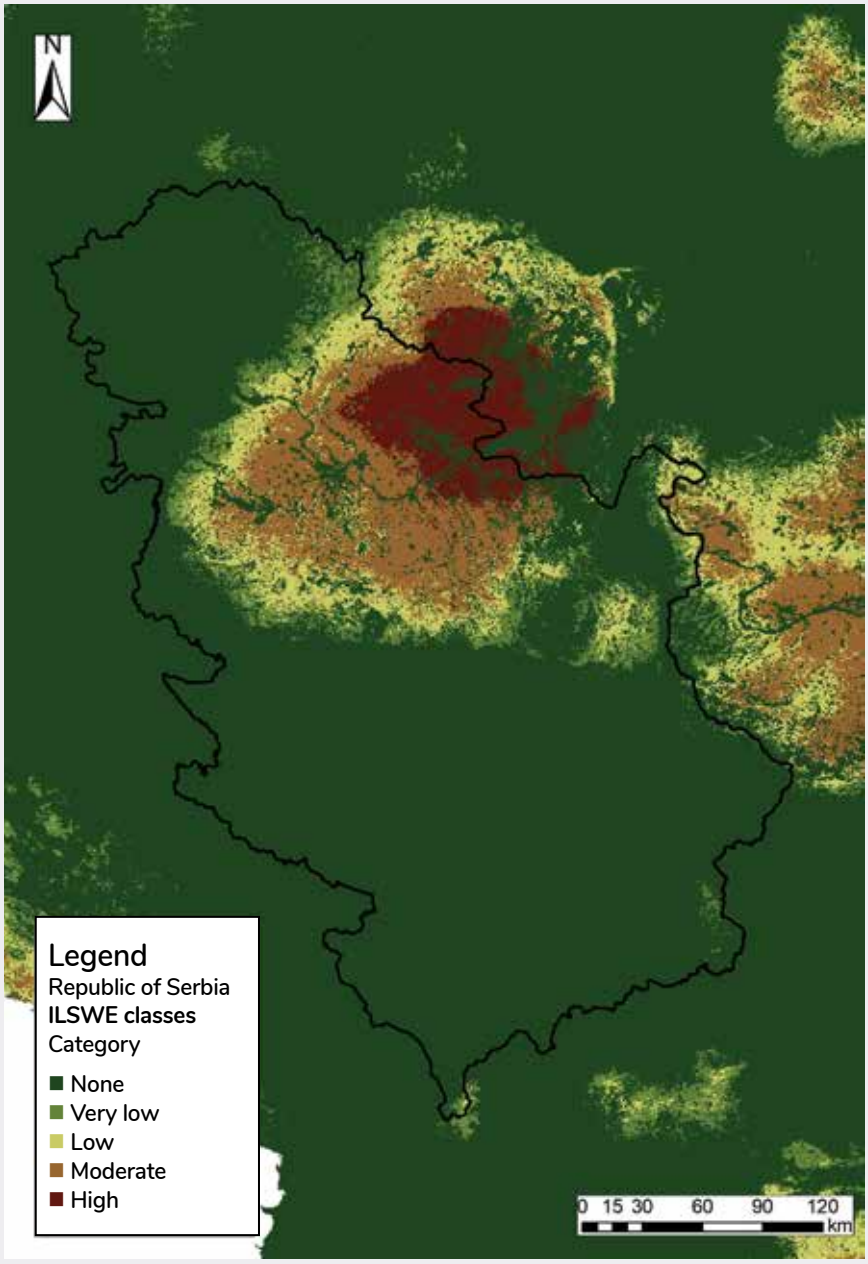


Figure 16. *Spatial distribution of the wind erosion susceptibility index ILSWE (Borrelli et al., 2015)*

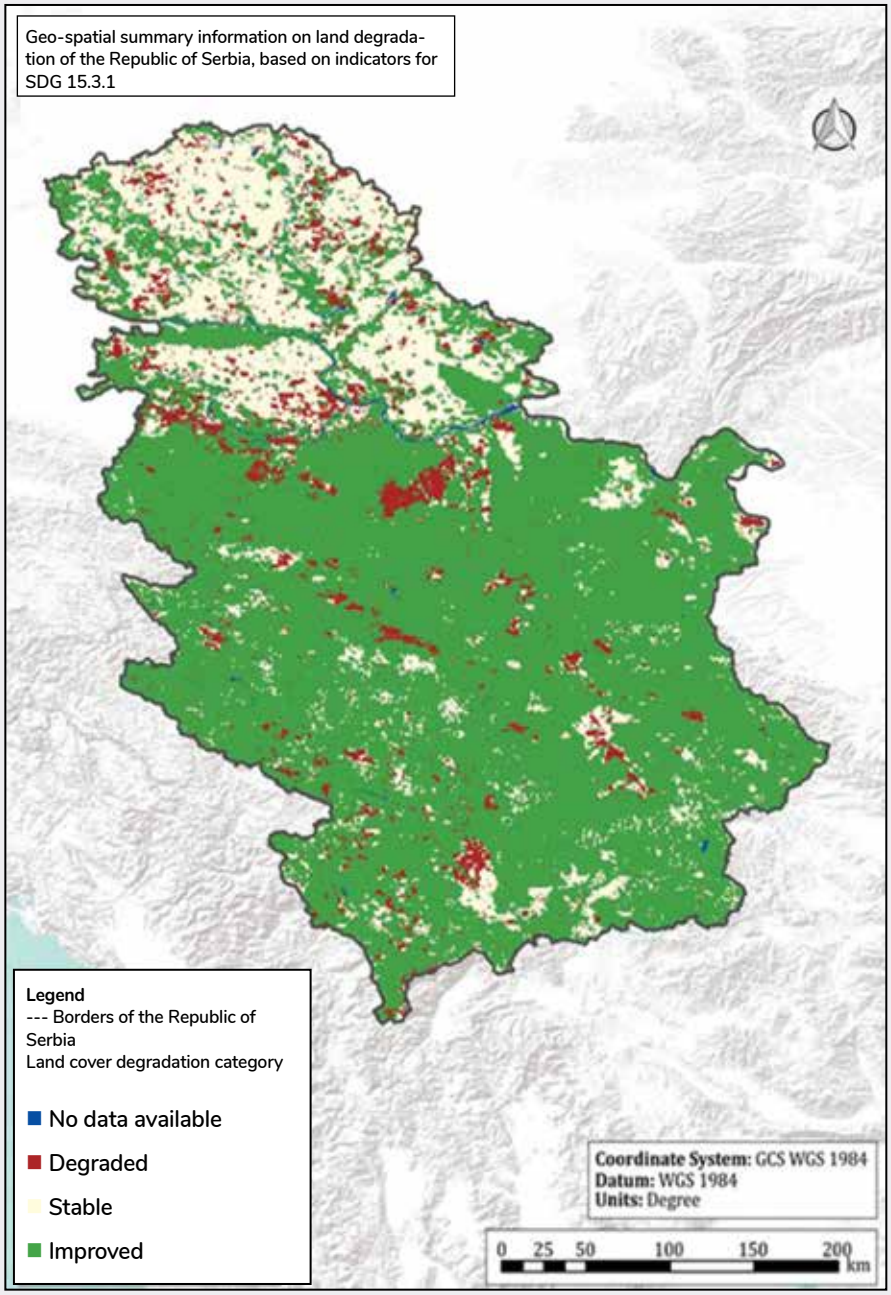


Figure 17. *Geo-spatial summary information on land degradation of the Republic of Serbia, based on indicators for SDG 15.3.1 (UNCCD, 2017).*

In order to address the issues of desertification and land degradation and establish sustainable mechanisms for management of this resource, the United Nations Convention to Combat Desertification is promoting the position that it is necessary to integrate the contemporary concept of Land Degradation Neutrality – LDN, as one of the objectives of sustainable development (Sustainable Development Goal – SDG). The concept of land degradation neutrality (LDN) has been introduced into the global dialogue in order to develop a more efficient approach to activities aimed at combating land degradation. The LDN has been adopted as a concept necessary in order to achieve the SDG 15 (SDG 15 – Life on Land) and building capacities in order to achieve LDN is among the most important activities of UNCCD.

The national LDN report was developed within the activities of the National Climate Change and Desertification Centre of the University of Belgrade Faculty of Forestry, with the support of the Global Environment Facility - GEF, the United Nations Environment Programme – UNEP, and the Food and Agriculture Organization of the United Nations - FAO[74]. The report was positively evaluated by the Special Working Group, established within the Ministry of Environmental Protection and was adopted by the UN Convention to Combat Desertification (UNCCD).

Since the Republic of Serbia does not have a publicly available collection of national data, with spatial and temporal attributes necessary to determine the LDN parameters, for the purposes of the report use was made of global data for identification of the baseline change trends, which were provided by the UNCCD, for time sections of years 2000 and 2015. The use of results of processing global data bases is temporary in nature, until the establishment of a representative national data base, relevant for analysis of degradation according to the LDN concept. Representative national data base should be established on the basis of detailed monitoring, in line with the harmonised and adopted methodology, by competent national scientific-research institutions.

The time span used for analysis of the baseline (in compliance with the determined methodology) covers a period of 15 years (from 2000 to 2015). By analysing three key sub-indicators, under the described LDN methodology (the manner of land use and the topsoil, land productivity and organic carbon content) „**hot spots**“ have been identified (areas of degraded status) at the level of administrative districts of the Republic of Serbia, separately for each sub-indicator. A general overview of changes, by degradation categories, classifies **72.86%** of the territory of the Republic of Serbia into the category of „**improved**“ land status, **20.54%** into the category of „**stable**“ status, while the total area of degraded land is **6.47%** of the total territory of RS. According to the generated map (Figure 17), the greatest share of degraded areas is in parts of Vojvodina, central and southern Serbia. Regions classified as „stable“ are areas which can easily move into the category of degraded land, in case of practicing inadequate methods of land use.

[74] Ristić R., Radić B., Polovina S., *Report on the applied methodology and identification of goals for establishing the neutrality of land degradation in the Republic of Serbia*, op. cit.

3.5.2. Identification of regions and smaller areas appropriate for afforestation

The Republic of Serbia has the lowest afforestation level

29.1%

compared with other countries of the Balkans, and the convincingly lowest level of afforestation is in AP Vojvodina

6.37%

some municipalities have afforestation levels lower than

1%

The Republic of Serbia has the lowest afforestation level (29.1%) compared with other countries of the Balkans, and the convincingly lowest level of afforestation is in AP Vojvodina (6.37%). In addition, the existing forest areas, mostly fragmented, are unevenly distributed, and consequently some municipalities have afforestation levels lower than 1%. At the same time, 75% of the territory of the Republic of Serbia is susceptible to different categories of erosion processes, with annual production of erosion material of about 30 million m3, of which more than 8 million m3 takes part in the transport of such material[75]. Wind erosion is dominant across the whole territory of AP Vojvodina, and in flat areas south of the Save and Danube rivers, mostly in valleys along the major river courses. Wind erosion causes significant damages in agriculture, road and railroad infrastructure and water management, with negative effects on the quality of the environment in settlements.

Since forests, forest plantations and protective windbreaks are the most valuable part of natural and close-to-nature ecosystems, they significantly improve the general quality of the environment through different useful functions. Protective and regulatory functions of forests are reflected in the air, water, soil, landscapes, noise, mitigation of climate change at global level through capturing carbon in the biomass, but also through the forests' social and cultural function[76]. Areas and spatial units which are favourable for afforestation are areas susceptible to flooding and wind erosion: agricultural areas; corridors around the canal irrigation networks; areas around water surfaces; settlements; corridors along road and railroad infrastructure. Areas around communal waste landfills also offer potential for afforestation. Of particular significance is the protection of water accumulations, which is achieved by afforestation of degraded and gravitating areas in order to reduce the discharge of sediments and pollutants. In AP Vojvodina several tens of thousands of hectares of land have been identified which are characterised by salinity, acidity and compactness, which can be subject to afforestation.

Agricultural land is exposed to different degradation processes, and one of the key prevention and protection measures is the establishment of protective windbreaks, which is at the same time the most efficient measure to minimise the effects of wind erosion.

[75] Ristić, R., Milčanović, V., Malušević, I., Polovina, S., "*Torrential floods and erosion as a dominant factor of land degradation in Serbia - the concept of prevention and protection*", *Land degradation and protection* [Electronic source]: thematic collection , University of Belgrade, Faculty of Forestry, ISBN 978-86-7299-242-7, Belgrade, 2016.

[76] *Strategy of Forestry Development of the Republic of Serbia, op. cit.*

Protective windbreaks can be distributed in two directions, perpendicular to each other, thus forming greater or smaller rectangular agricultural surfaces. Windbreaks constructed perpendicularly to the direction of the dominant wind are called key or longitudinal windbreaks, and those that are placed perpendicularly to the main windbreaks are called auxiliary or second-degree windbreaks. The main windbreak belts protect the soil and agricultural crops against the effects of the dominant wind, which causes major damages, while auxiliary belts protect against wind of lower force and frequency. Best effects are achieved when the main windbreak is ideally perpendicular to the direction of the dominant wind, which also applies to auxiliary windbreaks. If the actual situation so requires, this rule may be neglected, and the network of windbreaks should include all existing forest fragments, linear formations and groups of trees. Distance between windbreaks depends of land type, the wind force and frequency, intensity of wind erosion, the volume of evaporation, the duration and the height of snow cover. It is advisable to establish windbreaks at smaller distances, in unfavourable habitat conditions (poor quality and loose soil, stronger and more frequent winds, intensive evaporation and blowing away of soil particles).

Establishment of windbreaks is a favourable melioration measure on melioration cassettes, be it for irrigation or water control. Evaporation from soil surfaces depends of wind speed, air temperature, and also on soil humidity level. Very humid soil (up to 100% capacity) evaporates 40–50% more water than free water surfaces. In such a case, windbreaks reduce evaporation intensity and reduce the demand for water by 20–25%[77]. Additionally, forest windbreaks enable reduction of groundwater (bio-drainage), thus preventing creation of ponds and additional salination. Windbreak trees transpire great quantities of water, thus reducing groundwater levels by 50–80 cm compared to areas in between windbreaks[78], forming a convex line of groundwater, between two windbreak belts, similar to conventional drainage. During winter, due to lack of transpiration, these lines are equalised. By shading the open canals, protective windbreaks prevent their weediness and when located around water surfaces they reduce the discharge of soil particles from the gravitating surfaces. Efficient protection of water accumulations is achieved, among other things, though establishment of protective belts of width of 40–60 m and more, particularly in cases of steeper terrain. Windbreaks along canals should be 5–10 m wide on each side or 10–20 m, on one side only. Also, by creating shade they prevent mosquito larvae formation, which is possibly only in unshaded water[79].

In river valleys with a wide river course there is often a need to increase the height of spacious river bank terraces, which are mostly covered by bigger particles and thus have low or no fertility in view of agricultural production. Colmation results in reducing water speeds and sedimentation, which is achieved by constructing low embankments which establish colmation cassettes. There is also the auxiliary measure of forming protective belts located perpendicularly to the direction of the water flow, on the left or right river bank. Colmation belts contribute to raising the river bank levels and thus protect the land against flooding, runoff and sedimentation of unfertile particles. Afforestation should be performed in form of ilo-filters, or multilinear belts made up of trees and bushes with glass-leguminous cover in between lines.

In case of flash water courses, with strong inclinations and great share of barren land, it is favour-

[77] Lujić R., *Forest reclamation*, University of Belgrade, Faculty of Forestry, Belgrade, 1973.

[78] Jovanović S., *Forest belts*, Institute for Scientific Research in Forestry of RS, Belgrade, 1956.

[79] Lujić R., *Forest reclamation*, op.cit.

able to establish special types of windbreaks, the so-called „forest caps". They are established at hilltops or on prominent rocks in order to reduce the wind kinetic power, retain and better distribute snow and reduce the potential of fast surface influences. Forest caps are particularly efficient in areas of drainage divides or hilltops, if formation of trenches has started and the land is evaporated and has low fertility potential and is degraded by erosion effects.

Land corridors along first and second degree roads and municipal and uncategorised roads also offer spatial potential for establishment of windbreaks. In winter snow cover forms, along with fog and clear ice, threatening traffic safety. Snow drifts caused by wind blows reduce road visibility, causing traffic accidents and increasing travel times and cost of road maintenance[80]. Multi-lined forest windbreaks are an efficient means of protecting roads against snow drifts[81] because, among other things, they reduce road maintenance costs under winter conditions[82]. Their key function is reflected in physically cutting the direction of the wind blowing, causing snow accumulation on the sheltered side, outside the roads. In addition, protective windbreaks have a positive environmental effect, reducing CO_2 emissions[83], reducing fog formation, improving the physical-mechanical soil properties, reducing topsoil loss and creating conditions for biodiversity revitalisation[84]. Local agricultural roads make up a dense network of local transport lines, equally distributed, particularly in the territory of AP Vojvodina. This system of earth roads, with porous top layer, is delineating cadastre parcels and their key function is to enable access to farming machinery used in agricultural productions. Windbreaks along such uncategorised roads are placed so as not to form shade, in order to enable very quick drying in spring and autumn, and consequently timely working of the land and harvesting.

3.5.3. Establishing a GIS data base on existing and planned windbreaks in units of local self-government

The current achievements in applying GIS technologies enable imaging of real areas in digital form, or data bases adjusted for computer processing. One of the numerous possibilities offered by GIS is separating representative information on complex relations among factors involved in dynamic spatial processes. GIS enable adequate systematisation, analysis and finally presentation of all relevant spatial data. Using GIS in mapping protective windbreaks can be viewed in two ways. First, GIS can be used as a modern tool to collect and visualise data. The second aspect is related to the role of GIS as a data base, enabling archiving, updating, processing and analysis.

The use and establishment of GIS data bases provide a tool for a better quality, more efficient and more cost-effective approach to planning, establishing new and maintaining existing windbreaks. A GIS data base of windbreaks, generated as digital data, is linked to spatial and attribute data which, when linked among them by means of software

[80] Glavić, D., Milenković, M., Nikolić, M., Mladenović, M. N., "Determining the number and location of winter road maintenance depots–a case study of the district road network in Serbia", *Transportation planning and technology*, 41(2), 2018, pp. 138–153.

[81] Goodwin, L.C., *Best practices for road weather management*, Mitretek Systems Inc, Falls Church, 2003.

[82] Tabler, R.D., "Controlling blowing and drifting snow with snow fences and road design", *National Cooperative Highway Research Program Project*, 20–7(147), Tabler and Associates, Niwot, CO, 2003.

[83] Wyatt, G., Zamora, Z., Smith, D., Schroder, S., Paudel, D., Knight, J., Kilberg, D., Taff, S., *Research and Assess the Farmer and MnDOT Economic and Environmental Costs and Benefits of Living Snow Fences, Including Carbon Impacts*, University of Minnesota, Minnesota Department of Transportation, 2012.

[84] Velašević V., Đorović M., *Influence of forest ecosystems on the environment*, University of Belgrade, Faculty of Forestry, ISBN 86-7299-051-X, Belgrade, 1998.

module, make up a data base enabling graphical imaging. A potential expansion of this project to all units of local self-government (towns and municipalities) in Serbia, would result in creating a synthetic GIS data base of windbreaks.

Establishment of a GIS data base methodologically relies directly on the model of use of GIS systems, covering the following stages:

- Developing and inventory of spatial entities for elements of relevant area
- Determination of attribute data od identified entities
- Integration of data provided by relevant institutions (data on climate-meteorological conditions)
- Integration of data resulting from processing samples from field research work (soil characteristics)
- Creating a software link among all collected data
- Analysis and study

These stages in the course of developing a GIS data base will overlap due to the nature and dynamics of its development. The initial (preparatory) stage would consist of collecting existing information material for the purpose of developing the GIS data base in the relevant area (town, municipality, region), analysis of technical literature references, developing adequate methodology in line with the specific characteristics of the studies area, defining the levels of detail in collecting attribute data and defining the key based on which attributes are collected for certain entity characteristics.

This stage is followed by conducting field preparations for collecting spatial data and recording the components of windbreaks and their entities in the field. The elements of windbreaks include: tree alleys, bush vegetation or forest residues along road infrastructure (with hard or soft cover), canal networks, inland waterways, rivers and regulations, agricultural land.

Collecting spatial data would imply defining the two-dimensional geometry of key elements of the relevant area: for point-defined entities it is the centre of the entity (ex. tree); for linear entities it is all breaking points (hedges, water courses), and for the surface defined entities it is the boundary covered by the entity (ex. bushes, grassland). This is followed by topological and geometrical control of

the recorded content. Processing of collected data, their checking and verification would be conducted in a number of iterations, until a satisfactory accuracy level is achieved.

Defined spatial data would be used in specific steps as the basis for field collection of attribute data for entities subject to the specific area, representing vegetation elements (trees, bushes and hedges), using a predefined key for entry of attributes according to entity characteristics.

Attribute data after collection would be successively processed and correlated with spatial data, thus the data base would be formed during the field research work. The terrain work would include taking soil samples and conducting laboratory tests (basic physical and chemical characteristics). The resulting data on soil properties would be correlated with spatial data but these would be separate parts of the single data base.

In parallel with recording and collecting data, correlating spatial and attribute data, and the results of soils tests, the GIS data base would develop and be prepared to develop a WEB service, or the geo-portal[85].

The whole work process on establishing the GIS data base would be conducted in several stages, during which the work of all engaged experts would constantly overlap until achieving the required level of accuracy and adjustments, which would be followed by analysis and study research, as the finals stage. Figure 18 presents schematically the process.

Collection of data regarding locations would be conducted in iterations. The first iteration would be the initial definition and it covers most of the spatial data. Subsequent iterations, additional definitions, have a control function and the role of removing possible weaknesses. The data collection method is primarily dependent on site characteristics (ex. park surfaces in urban areas, with significant share of high vegetation), disabling the use of GNSS technology (global navigation satellite system) and remote detection. Additionally, the required accuracy level of at least 5 cm for detail, which can be clearly identified (artificial entities) and the level of detail in recording vegetation would impose terrestrial measuring methods, such as the polar method, as the optimal choice for the method of details recording.

[85] World Wide Web.

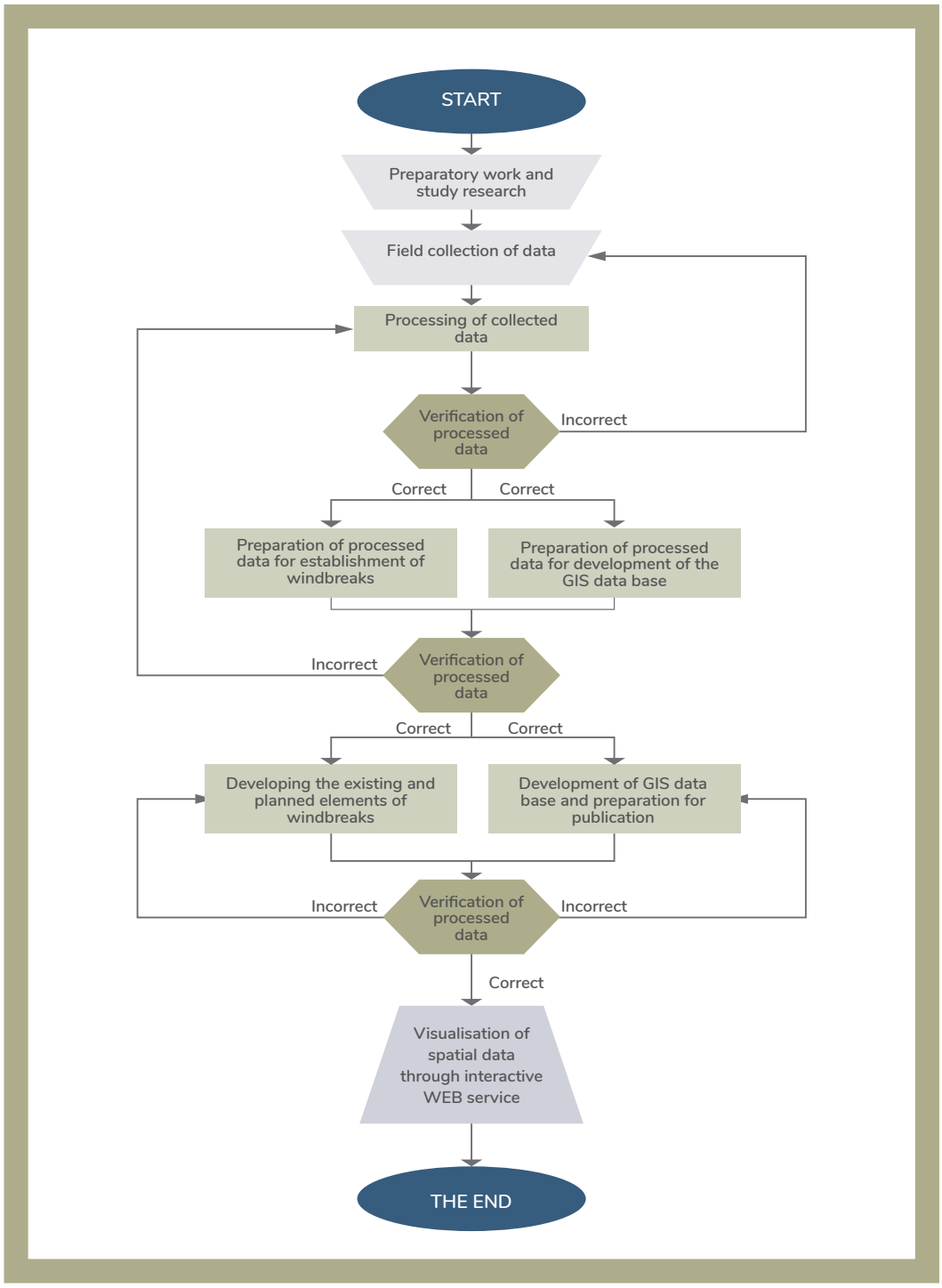


Figure 18. *Diagram of activities during the development of the GIS data base (Authors)*

The choice of the reference framework for presentation of the collected data relates to the implementation of the geodetic baseline for recording of details and the choice of the coordination system and projections, for presentation of recording results. For the purposes of recording and the basic presentation of collected data, it is proposed to use presentation in the official state coordination system of the Republic of Serbia. The results of collected data would be presented in CAD (.dxf) and GIS (.shp) formats. The CAD format is used primarily as the working format, in order to develop the working sketches to be used as an auxiliary tool while collecting attributes in the following stage of developing the GIS data base. The GIS format is designed so as to enable the extension of the spatial data base by additional information and to enable updating the changes which occur in the meantime. The basis of the spatial data base consists of vector data models presented as dots, lines and polygons, on the basis of collected spatial data. Each GIS data base should include data on the occupied surface area (parks, forest residues, etc.), the linear elements (tree alleys, green corridors and water courses) and individual entities (trees).

For every recorded element of the windbreaks a code is assigned (identification number), providing information about the type of the element, its location, type of vegetation and the serial number in the green space.

The basic data to collect for trees:

- Location in real space (coordinates Y, X in Gauss-Kruger projection);
- Type of vegetation;
- Name of species in the Latin and Serbian language;
- Tree height;
- Tree height without branches;
- Chest diameter of the tree;
- Width of canopy;
- Presence and type of damage;
- Assessment of vitality and decorative value;
- Photographs of the tree and damages.

The basic data collected for bushes:

- Location in real space (coordinates Y, X in Gauss-Kruger projection);
- Type of vegetation (point or surface area);
- Name of species in the Latin and Serbian language;
- Height of bush
- Number of pieces in a group (if surface entity);
- Diameter of the bush (for 1 bush) or length of bushes (hedges);
- Surface area;
- Presence and type of damage;
- Photographs of bushes and damages.

Identification of woody or bush taxons and type of vegetation would be conducted in the field. Basic taxonomic rules would be applied for this as prescribed by botanical nomenclature and plans species nomenclature: name of taxon, species, and names of cultivars (with single quotation marks). In case of doubt, available material would be collected (leaves, flowers, fruits, seeds, twigs, bark, etc.) and identification would be made subsequently by using the key for identification of species and literature references.

In addition to the attributes such as height of tree, there would be also the attribute category of tree based on tree height, where trees would be classified according to given categories (ex. young tree, low tree, medium tree, high tree, etc.). Height of tree without branches is measured from the ground level to the first (lowest) branches. Heights up to 2 m (according to Serbian standards for seedling material of decorative trees and bushes, 2015), or up to 2.4 m (ANLA standards), are the heights which for reasons of safe passage under the canopy are taken as relevant measurements. Height of bush species would be expressed by the attribute height in line with the defined criteria, in order to simplify data handling. Width of canopy would be measured using measuring tapes. In case of symmetrical canopies, the value would be expressed in single digits, as the sum of two digits (width from tree centre to one side and the other side of the canopy). Measuring the frontal diameter of the tree would be done at „chest“ height (1.30 m), using a measuring device for this purpose. The diameter is determined as the arithmetical mean value of two cross measurements and expressed in cm. The coverage surface area of bushes would be expressed in m^2, as surface area covered by individual bush or group of bushes.

Presence and type of damage would be identified based on symptoms observed in the field. Types of damage would be classified as mechanical (breaking of branches, dry branches, dry tops of canopies, breaks or cuts of thick branches in the canopy) and physiological (stating the effects of environmental factors on tress growth and development: lack of water, soil impacts, light or pollution impacts). In case of presence of any of these weaknesses, the GIS data base should provide a recommendation for a detailed analysis (tests of soil of physiological parameters for vitality assessment); entomologic and phyto-pathological damage which has been recorded, along with recommendation for detailed expertise by experts for protection of tree and bush species.

After ranking of elements of windbreaks and identifying the most valuable elements, as well as those with the worst status, a vitality assessment would be conducted as a separate attribute in the GIS data base, based on the health status and development of each individual item. This assessment is an important basis for the development of reconstruction projects, due to the possibility to identify and separate items of low value (which should potentially be removed), as well as valuable items which should be protected and preserved. The vitality assessment would have a scale with numerical quantification of elements of windbreaks, starting from those that are completely healthy and exceptionally vital, to those which are sick, damaged or dry.

In addition to the vitality assessment, another significant parameter is the general status evaluation, or decorative value, which very much depends on vitality, but also on the position in which these items grow, their even development, attractive form in the right location, etc. The evaluation of decorative value is based on characteristics specific to every species, and it uses numerical and descriptive characteristics. The scale for the evaluation of decorative value starts from items without decorative features to those with excellent decorative features.

When collecting spatial data, each recorded item (tree, bush, hedge, etc.) is assigned a unique iden-

tification number, which is recorded in the basic spatial data base as a separate attribute. Qualitative vegetation data would be collected in the field using pre-designed work sheet tables which, in addition to columns with vegetation characteristics (name, deciduous/conifer, chest diameters ...) would include also a column with already collected identification numbers. This would enable vector data in the spatial data base to be uniquely joined with qualitative data on vegetation characteristics, based on common attributes, unique ID numbers. Joining qualitative attributes (in the form of table - *.xls format) spatial data (*.shp format), would be done within the GIS environment, using the option "Join", by joining the item in a relation 1 on 1 (Figure 19).

INPUT

Spatial data in GIS environment (*.shp format)		
OBJECT ID	Shape	ID_Number
1	Point	2
2	Point	0
3	Point	1

option JOIN

+

Qualitative attirbutes in Excel environment (*.xls format)		
ID_Number	Deciduous _conifer	National_name
0	deciduous	common oak
1	conifer	Austrian pine
2	dry tree trunk	/

OUTPUT

OBJECT ID	Shape	ID_Number	ID_Number	Deciduous_conifer	National_name
1	Point	2	2	dry tree trunk	/
2	Point	0	0	deciduous	common oak
3	Point	1	1	conifer	Austrian pine

Figure 19. *Diagram of joining attributes to spatial data (Authors)*

After establishing the GIS data base of windbreaks, as part of the overall spatial data base, data should be publicly available (on internet). Developing a Web GIS application or a geo-portal would enable all users, both professional and others, by using web browsers to simply get insight into spatial data. Such an approach is necessary for sharing and presenting spatial data among a number of users, in order to avoid duplication, inconsistency in data, delays and wasting of resources and information. Web GIS, or geo-portal, would enable users to have online access to processing and editing spatial data, creating conditions for linking existing items of windbreaks in units of local self-governments.

3.5.4. The concept of „green“ areas in units of local self-governments linking the greenery of urban and rural regions

The United Nations Human Settlements Programme - UN Habitat - is a programme working on contemporary issues in settlements development. It was established in 1978, in order to monitor the process of increasingly intensifying urbanisation, and in 2002 it became an official UN programme. Global data and trend analyses have led to the position that the urban population will double, with significantly intensified economic social and cultural interactions, with significantly more complex relations with respect to environmental resources. That was the motivation for the UN Conference on Housing and Sustainable Urban Development (2016 in Quito, Ecuador) to adopt the „**New Urban Agenda**“. The Agenda was adopted by heads of states and governments, ministers and high officials of UN member states, including the Republic of Serbia as a full member.

The Agenda defines the principles that UN member states shall be guided by when planning, designing, funding, developing and managing cities and settlements, in the context of global climate change.

The Agenda emphasises the need to achieve urban and rural development respecting the needs of the modern man, with efficient environmental protection and rational use of natural resources.

In addition to that, it stresses the necessity to provide support to spatial systems integrating urban and rural functions, in national and sub-national contexts, thus promoting sustainable management and utilisation of natural resources and land, ensuring reliable supply chains and linking urban and rural supply. Establishment of windbreaks between urban and rural areas promotes interaction and linking of rural and urban actors, with the support of planning instruments based on integrated spatial approach in terms of greater territorial cohesion, as well as environmental security and sustainability. Thus, protective windbreaks are a means directly implementing the objectives of the „New Urban Agenda“.

The „Strategy of Sustainable Urban Development of the Republic of Serbia until 2030", in the part related to identifying strategic objectives to improve the quality of life in urban areas, underlines the need to strengthen and improve rural-urban links, by implementing projects which improve the quality of ecosystem services[86].

3.5.5. Identification of the potential for networking of existing areas of nature protection, environmental corridors and protective windbreaks

The concept of biodiversity comprises all phenomena of the living world on planet Earth, from individual species to whole ecosystems. As a result of multi-millennial evolution, the Earth today is populated by several million different plant and animal species. However, over the recent decades the level of biodiversity has rapidly started to decline, as a result of direct and indirect impacts of anthropogenic factors and climate change. Urbanisation, felling of forests, exploitation of mineral raw materials, land degradation, production of pollutants endangering the air, soil, and water are just some of the factors with massive destructive effect on the overall living world. Biodiversity reflects complex ecosystem relations which significantly exceed the simplified statement regarding the „wealth of species", so that its decline has impact on disturbing functional relations within habitats, the loss of certain species and loss of genetic information. In the world of global degradation of natural resources biodiversity has become the key indicator of the state of the ecosystem. Although the process of declining and rising biodiversity is a part of the natural process, it has been unequivocally determined that extinction of species in present time is incomparably faster than in the past. A particularly relevant consequence of loss of biodiversity is the impact on global economy, which to a great degree (almost 40%) depends on biological products or processes. Although it is difficult to estimate the monetary value of biodiversity reduction, an estimate was made at the end of the 1990's of USD 33 billion annually (1.8% of the global national product). More recent research provides a much more pessimistic forecasts: the two-day ninth meeting of the Conference of Parties of the Convention on Biological Diversity presented a research forecasting the loss of EUR 14 trillion until 2050, representing 7% of projected gross national product of all countries in the world. Based on such facts and forecasts, international institutions and individual countries have in recent decades worked intensively on establishing legislative and institutional frameworks to slow down the decline of biodiversity at different spatial levels, from global, through regional and national, to the local level.

During 2020, the European Union has adopted

the „EU Biodiversity Strategy to 2030"

with the accompanying

Action Plan

These two documents are a comprehensive, ambitious and a long-term plan to protect nature and reverse further degradation of ecosystems. The objective is to create conditions for the recovery of European biodiversity until 2030, with benefits for the humanity, the climate and the Planet. This activity is harmonised with the forthcoming international negotiations on the global framework for biodiversity after 2020. The significance of these activities is obvious also from the perspective of the global COVID 19 pandemic and the necessary evolutive changes of the contemporary world, in

[86] *Strategy of Sustainable Urban Development of the Republic of Serbia until 2030* (Official Gazette RS, No. 47/2019-4)

order to build a more resilient system with respect to climate change, food production safety, natural disasters or pandemics. The Strategy includes specific commitments and actions to be achieved until 2030, including:

- Establish a larger EU-wide network of protected areas; enlarge existing protected areas (particularly those from the Natura 2000 network); strict protection for areas of very high biodiversity;
- Nature restoration plan, through restoration of degraded ecosystems across the EU by 2030; sustainable management in order to eliminate key drivers of biodiversity loss;
- Set of measures enabling the necessary change in order to preserve biodiversity: launching a new, strengthened governance framework to ensure better implementation and tracking of progress; financing and investments; higher level of nature protection through consistent enforcement of regulations and articulation of ethical norms in public and private sectors;
- Participation in activities for global biodiversity protection, in line with the principles of the Convention on Biological Diversity.

The new EU Biodiversity Strategy, like the previous ones, supports the theoretical and practical approach in nature protection, through establishment of systems of protected areas where natural processes will evolve with minimum impact of anthropogenic factors. This leads to achieving the objectives of protection based on affirmation of the authentic landscapes, preservation of the quality of natural assets, biological and geological diversity. Environmental corridors enable significant habitats (network nodes), which are spatially distant, to be linked and function as a system. In order to establish a coherent and resilient trans-European network of natural areas it is necessary to establish environmental corridors in order to prevent genetic isolation, enable the migration of species, preserve and enhance ecosystem stability. In this context, it is necessary to plan and support investments in „green“ and „blue“ infrastructure, and ensure cross-border cooperation among member states but also with other states in the European continent. Contemporary approaches to spatial planning see environmental networks as an important instrument of nature protection with numerous ecosystem functions and services.

According to the European model, and based on the nature protection strategy and the national legislation, the Republic of Serbia plans to establish an environmental network in order to enhance, protect and more efficiently manage protected natural assets. According to the *Law on Nature Protection*[87] („Official Gazette RS“ No. 36/2009), an environmental networks is a „set of interconnected or spatially close protected areas and environmentally significant areas enabling free movement of genes and significantly contributing to preserving the natural balance and biological diversity within which individual parts are linked to naturally or man-made environmental corridors“. Environmental networks are recognised as an adequate means to ensure and achieve optimum conditions for life of endangered plant and animal species and their habitats, by implementing protection, preservation and sustainable use measures as defined in management plans. In addition to that, environmental networks are recognised as an important element of local community identity, since they cannot be established without the presence and action by anthropogenic factors, in line with the principles of nature and environmental protection.

[87] Law on Nature Protection, *Official Gazette RS* No. 36/2009

The umbrella document which defines and institutionalises the concept of nature protection, through the modalities of establishing environmental network, is the **Decree on Environmental Network**[88]. The key task of this decree is to formally prescribe the definition and the nature of environmental network and ways of managing and financing the elements thereof in order to preserve biodiversity.

Thanks to this document, more than 100 environmentally significant areas have so far been identified in the territory of the Republic of Serbia, with the function and the form of an environmental network.

As environmental corridors of international significance, the following watercourse and their riverbank areas have been recognised in the territory of the Republic of Serbia: the Danube, Tisa, Sava, Drina, Južna and Velika Morava, Tamiš, Kereš, Zlatica, Karaš, Nera, Brzava, Moravica, Bosut and Studva. In addition to these, environmental corridors at a lower spatial and organisational levels (regional and local) could include watercourses which are in the natural or close-to-nature state (more natural regulation forms) and amelioration canals which along their river banks have elements of natural vegetation. Additionally, an important role in the environmental network is played by non-linear landscape elements which enable structural and functional connectivity in the landscape structure, such as fragments of protective windbreaks, hedges, etc.

According to the decree, management of the environmental network enables long-term preservation and maintenance of the optimal status of environmentally significant areas and environmental corridors, and preservation and enhancement of functional and spatial connectivity of its parts. With respect to the components of the environmental network belonging to environmentally significant areas and environmental corridors, the following measures are prescribed which are relevant also for forest protective windbreaks:

[88] Decree on Environmental Network, *Official Gazette RS* No. 102/2010

- Prohibition of destruction or endangerment of habitats and prohibition of any activity disturbing wildlife species;
- Prohibition of changing the intended use of areas under natural or semi-natural vegetation;
- Prohibition of changing morphological and hydrological features of areas that functionality of corridors depends on;
- Planning the intended use of such areas and active protection measures in order to preserve and enhance natural and semi-natural elements of corridors with landscape and vegetation features of the area;
- Improve environmental corridors within construction areas, by establishing a continuity of green areas whose structure and functions support the functions of the corridor.

With respect to elements of the environmental network belonging to the same zone of protection with the role to protect environmentally significant areas against possible harmful exterior factors, measures are prescribed which are also relevant to forest protective windbreaks:

- Through zone distribution of urban and rural functions, and by applying adequate technical-technological and other solutions, eliminate or mitigate negative impacts on the living world;
- When using natural resources the preservation of the hydrological regimes should be preserved in order to ensure the functionality of the environmentally significant areas and/or environmental corridors;
- Stimulate the establishment of protective greenery along the borders of environmental corridors, in line with the needs in terms of species and habitat types in the area.

It is possible to conclude from all of the above that protective windbreaks, as part of local environmental corridors, have an important role in improving biodiversity at local level and that in the course of their planning/design it is necessary to strive to achieve structural and functional links with protected natural areas and with elements of environmental corridors at regional and international level.

3.5.6. Establishing potential "blue-green" corridors and "blue-green" islands (open water surfaces with accompanying windbreaks)

The "blue-green" corridors are a system of open watercourses linked with forest areas or fragments thereof in the direct vicinity of their banks or on slopes of the watershed areas. The concept of "blue-green" corridors was developed by the Faculty of Forestry of the University of Belgrade as a result of efforts to achieve integration of contemporary environmental solutions and sustainable development of urban systems. The key idea behind the concept is promoting the significance of water bodies of surface waters (lakes, accumulations, brooks, rivers or canals or parts of brooks, rivers or canals) and their inundation regions („blue" corridors), as areas characterised by favourable environmental features, with the potential to promote sports-recreational activities, in line with the highest standards of preserving natural values, which are linked with „green" corridors (linear tree formations, forest residues, groups of trees, hedges).

The "blue-green" corridors and "blue-green" islands are very significant for preservation and improvement of local and regional biodiversity, prevention and control of flash floods and erosion processes, and have a positive impact on reducing the heat island effects.

As a rule, "blue-green" corridors and "blue-green" islands should, in addition to occupying water bodies, also occupy the so-called "water bearing land". According to the *Law on Waters*[89], water bearing land is land having water permanently or temporarily, creating specific hydrological, geomorphological and biological relations, and which are reflected in the aquatic or coastal ecosystems. Water bearing land with running water (area for "blue-green" corridors) is either the river bed for big waters or the coastal land. Water bearing land of standing water (area for "blue-green" islands) is the riverbed and the coastal belt of land along the bed of standing water up to the highest recorded water level. Waters and water bearing land is public property and inalienable public assets. According to the said law, public water assets may be used in a manner

[89] Law on Waters, op.cit.

which does not have negative consequences to the waters themselves and the coastal ecosystem and which does not limit the rights of others. The width of the coastal area is 10 meters, in regions not protected against flooding (Article 9, item 1), or up to 50 meters in areas with flood protection (Article 9, item 2), calculating from the lower end of the embankment towards the protected area[90]. The Ministry of Agriculture, Forestry and Water Management and, the competent authority of the AP, may determine different widths of coastal areas, if so necessary in order to achieve: protection of water, aquatic and coastal ecosystems; regulation of waters; protection of assets of special value and capital assets; performance of other tasks of general interest.

There is, however, certain lack of logic related to legal (property) identification of water bearing land in the cadastre of immovable property, as the basic public registry of immovable property. Namely, although the *Law on Waters* provides clear provisions on water bearing land, and specific ways of managing this land, the cadastre does not recognise the category of water bearing land. For this reason, it sometimes happens that areas recognised by the Law as water bearing land are utilised as construction land or are exploited as agricultural land. According to the Law, the ministry in charge of water management and the competent authority of the autonomous province are obliged to determine the boundaries of water bearing land registered in the cadastre of immovable property.

3.5.7. Identification of areas appropriate for sports, recreational and relaxation contents (cycling and hiking tracks; open exercise grounds; resting places; children playgrounds and contents for adults with disabilities)

Since windbreaks, as linear corridors, are the „axis“ of the new „green“ infrastructure, it would be desirable to utilise this potential to make lateral links with all nearby and preserved valuable „green“ areas (forests, residues of forests, dense bushes and hedges and meadows) and „blue“ elements (rivers, brooks, natural and artificial lakes). In the course of developing planning and technical documentation the protective role of windbreaks is analysed along with considering the possibility to achieve certain functions of general public and environmental functions and introducing content attractive for the local population and potential tourists. Windbreak systems should be viewed also as areas appropriate for sports and recreation and content with tourism potential. It is also necessary to consider all nearby sites of cultural-historical, touristic, esthetic and spiritual significance, such as: exceptional lookouts (observation sites), offering exceptional view of the surrounding areas; buildings of historical and cultural significance; vicinity of great rivers; segments of preserved nature; agro-tourism facilities, especially farms producing food in line with standards for organic food production; eco-tourism facilities.

[90] *Ibid.*

Within windbreaks or in their direct vicinity it is possible to establish the following contents:

- Systems of pedestrian-cycling tracks, with the accompanying contents (benches; shading sites; public lighting)

- Outdoor exercise grounds

- Children playgrounds

- Outdoor resting sites

- Sports-recreational contents for children and adults with disabilities (playgrounds; resting sites; horticulture therapy gardens).

Pedestrian and cycling tracks can be combined or separate, if there is sufficient space, conditional on the width of the windbreak. The minimum width of pedestrian-cycling tracks should be 4 meters. If the tracks are separate, the width should be 3 meters for cycling tracks and 2 meters for pedestrian tracks.

In certain locations, in the direct vicinity of the windbreaks, it is possible to establish multifunctional areas, up to 400 m^2, with the following contents for users (pedestrians or cyclists): shading sites, benches, information points/boards (stating key data on the location; historical information; natural characteristics, etc.). Multifunctional areas are formed in locations adequate for resting, on exceptional observation points and in the vicinity of historical-cultural sites.

Particular attention should be paid to arranging the direct surroundings of the windbreaks. It is necessary to raise awareness of the local population regarding the value of natural potential of the area. Both in terms of use and in terms of preservation. Practically, all landfills and waste disposal sites should be removed from the areas around the windbreaks, which requires operation of responsible citizens. If citizens recognise their own responsibility for protection of the area, this creates preconditions for the area to develop attributes of authentic „green“ or „green-blue“ oasis. Achieving this goal requires raising awareness of citizens though lectures, open debates, development and dissemination of printed materials and workshops. Active media involvement should be ensured and the professional and general public animated.

3.5.8. Identification of institutions/organisations which can manage and maintain the newly established windbreaks

Spatial coverage, significance and multifunctionality of the windbreaks systems require the establishment of an independent management unit, in form of a public enterprise or company, under the control of the Ministry of Agriculture, Forestry and Water Management and/or the Ministry of Environmental Protection. These units can partly be funded from the national budget and partly from international funds (that Serbia has access to), and partly through fees collected from all users utilising the benefits of windbreaks (agriculture, water management, road and railroad transport, energy gen-

eration). Funds resulting from collected fees should be used for ear-marked purposes, exclusively for financing of existing windbreaks and planning, constructing and maintaining new ones.

3.5.8.1. Proposal for classification and management system for windbreaks in the Republic of Serbia

In terms of their significance, windbreaks are divided into:

A) State owned windbreaks.

- A1) 1st class state-owned windbreaks (along first class roads; in watershed areas of accumulations used for water supply; along railroads; along international inland waterways; as part of or link between key environmental corridors);
- (A2) 2nd class state-owned windbreaks (along second class roads; along the Dunav-Tisa-Dunav canal system; along 2st class watercourses; around tailings ponds or power generating facilities of national significance; in protected areas of national significance (national parks, parks of nature, special nature reserves);

B) Municipal windbreaks (along municipal roads, in urban and rural areas; along 2nd class watercourses; around water bodies, landfills and tailings ponds; as part of system of „blue-green“ corridors);

The Government should prescribe the classification criteria for windbreaks, adopting relevant acts, while the minister in charge should form a commission to verify the fulfilment of criteria for windbreaks categorisation.

Assemblies of units of local self-government shall adopt acts on classification of windbreaks.

Managing state-owned windbreaks is an activity of general interest and includes:

- Planning, design, establishment, reconstruction, maintenance and protection;
- Exercising the investor's function related to design, construction, maintenance and reconstruction;
- Organising and conducting technical tasks related to planning, design, establishment, reconstruction, maintenance and protection;
- Contracting works related to design, construction, maintenance, reconstruction and technical oversight;
- Organising technical oversight of construction, reconstruction, maintenance and protection;
- Monitoring;
- Protection;
- Marking and keeping records of state-owned windbreaks, including key technical data.

The activity of managing state-owned windbreaks is conducted by a public enterprise or a company owned by the Republic of Serbia.

The activity of managing 2nd class state-owned windbreaks or parts thereof located in the territory of autonomous province is conducted by a public enterprise or a company fully owned by the Autonomous Province.

The activity of managing municipal windbreaks, which are not part of state-owned 1st or 2nd class windbreaks, may be performed by a public enterprise or a company fully owned by the unit of local self-government or another company or entrepreneur to whom the local authority has delegated the activity of managing municipal windbreaks, in accordance with the law regulating public-private partnership and concessions.

State-owned forest protective windbreaks may be managed also by institutions which managed such a windbreak until the day of coming into effect of

the law regulating windbreaks, provided that it fulfils the requirements prescribed by law and special regulations.

State-owned forest protective windbreaks may be managed also by a state-owned public enterprise or company founded by a unit of local self-government which managed such a windbreak until the day of coming into effect of the law regulating windbreaks, provided that it fulfils the requirements prescribed by law and special regulations.

3.5.9. Overview of the legal basis for preparation of technical-planning documents (valid laws, spatial/urban planning documents, urban planning documents, strategic documents)

3.5.9.1. The existing legal framework

As already stated, the issue of windbreaks is regulated in the following valid laws of the Republic of Serbia:

- **Law on Forests** ("Official Gazette RS", No. 30/2010, 93/2012, 89/2015 and 95/2018 - other laws), Articles 5, 8 and 70;
- **Law on Agricultural Land** ("Official Gazette RS", No. 62/2006, 65/2008 - other laws, 41/2009, 112/2015, 80/2017 and 95/2018 - other laws), Articles 18 and 19;
- **Law on Waters** ("Official Gazette RS", No. 30/2010, 93/2012, 101/2016, 95/2018 and 95/2018 - other laws), Article 16;
- **Law on Roads** ("Official Gazette RS", No. 41/2018 and 95/2018 - other laws), Article 87.

The existing legal framework does not allow an integrated approach to the issue of windbreaks due to a series of obstacles identified in practice so far:

- Absence of an initial, highest planning document, with the spatial layout of the system of windbreaks, for the whole territory of the Republic of Serbia, and for the territories of autonomous provinces, administrative districts, and units of local self-government;
- Absence of legal-financial mechanisms to address the issue of land ownership, which is identified as suitable for establishment of windbreaks;
- Absence of legal-financial mechanisms in the process of establishment, care, maintenance, reconstruction, and utilisation of windbreaks.

3.5.9.2. The existing spatial-planning and strategic framework

At the same time, the existing spatial-planning and strategic documents provide a sound basis for planning of windbreaks system, through the adopted goal of increasing the level of afforestation of the Republic of Serbia:

- **„Spatial Plan of the Republic of Serbia 2010 - 2020"** (*The Law on the Spatial Plan of the Republic of Serbia 2010 - 2020*, „Official Gazette RS", No. 88, 2010);
- **„Regional Spatial Plan of AP Vojvodina until 2020"** (JP „Institute for Urban Planning of AP Vojvodina", Novi Sad, 2011);
- **„Water Management Strategy of the Republic of Serbia"** (Institute for Water Management „Jaroslav Černi", the Ministry of Agriculture and the Ministry of Environmental Protection, 2015);
- **„Report on applied methodology and identification of targets to achieve land degradation neutrality in the Republic of Serbia"** (the Ministry of Environmental Protection, 2019).

The Ministry of Environmental Protection in January 2020 submitted to the Secretariat of the United Nations Convention to Combat Desertification-UNCCD its report, its „Report on the applied methodology and identification of targets to achieve land degradation neutrality in the Republic of Serbia“[91]. In order to address the issues of land degradation and establish sustainable mechanisms to manage this resource, the United Nations Convention to Combat Desertification-UNCCD is promoting the position that it is necessary to apply the contemporary concept of Land Degradation Neutrality – LDN, as one of the goals within the Sustainable Development Goals – SDG 15.3. Afforestation, with a significant share of municipal land under windbreaks, is the dominant measure of the national LDN report.

3.5.9.3. The issue of windbreaks through the planning-strategic measures and instruments for implementation of the „Spatial Plan of the Republic of Serbia 2021-2030“

The planning-strategic measures and instruments for implementation cover a set of sectoral documents which need to be developed and adopted (strategies, plans, designs, programmes, studies and the like), in order to provide the basis and support for implementation of individual planning solutions. The draft „Spatial Plan of the Republic of Serbia 2021-2030“ defines planning-programming measures and instruments for implementation for such areas which are missing, with emphasis on the spatial aspect in their development, which can be taken into consideration also when developing the concept of establishing windbreaks, specifically:

- **In the field of agricultural land, agriculture and fisheries:** designs for remediation of contaminated sites; programmes for protection erosion susceptible land; studies for sustainable use and protection of permanent grassland in mountainous areas; fruit-growing zoning programmes;

- **In the field of forestry, forest land and hunting:** developing the Programme of Forestry Development and development plans for forest areas (with the principles of management by management units), Strategy of Hunting and development plans for hunting areas; developing the Strategy and the Study for establishment of windbreaks in Republic of Serbia (with guidelines for establishment of agri-protective, suburban and protective forests, protective forests for reduction of imissions from industrial centres and transport infrastructure, protective forests for water accumulations, reducing the impact of erosion and flash floods, recultivation of tailings ponds and surface mines , etc.), with action feasibility plans for project financing;

- **In the field of water and water management infrastructure:** planning and technical documentation for hydro-energy facilities; studies for accumulations; development of watershed management plans;

- **In the field of raw materials and mining:** cadastre of abandoned mines and mining facilities in the Republic of Serbia with rehabilitation and remediation measures;

- **In the field of urban systems and development of urban settlements:** reviewing the existing or developing new sustainable urban development strategies at local level, in accordance with the *Strategy of Sustainable Urban Development of the Republic of Serbia until 2030* and defined strategic objectives and priority intervention areas; reviewing the urban plans for urban set-

[91] Report on the applied methodology and identification of targets to achieve land degradation neutrality in the Republic of Serbia, NO: 337-00-4/2020-04.

tlements with respect to reducing the planned coverage of their construction areas;

- **In the field of rural development and rural settlements regulation:** develop a feasibility study for financing of animal husbandry projects in a series of hilly-mountainous pastures; develop the agri-forestry programme (combined growth of woody multiannual plants and farming crops in certain spatial arrangements, or at successive times; studies for full evaluation and sustainable use of agricultural areas with high landscape value (with boundaries of such types of agri-biodiversity);

- **In the field of tourism:** develop the Strategy of Tourism Development of the Republic of Serbia for the period 2025-2035, sector programming and plan documents for tourism destinations which so far have not been fully developed and plans for secondary tourism areas, as well as develop sector strategies for development of tourism clusters and sector programmes for development of primary roads and inland waterways, urban, spa and mountain tourism centres; conduct studies of integrated management for tourism destinations with natural and cultural heritage;

- **In the field of environmental protection:** conduct the study of spatial differentiation of the environment with identification of conflicting areas, negative impacts zones and degradation points, with action plans; develop air quality plans for urban centres and settlements, particularly those most strongly affected; characterisation plans and remediation projects for priority contaminated sites; National strategy for managing contaminated sites with the accompanying action plan; and strategic noise maps for major cities and towns located in the vicinity of busy transport systems;

- **In the field of waste management:** develop the National waste management strategy with the National waste management plan for the period 2020-2025, as well as regional and local waste management plans; conduct studies to determine locations for radioactive waste disposal in Serbia and studies to determine the location of hazardous waste disposal site in Serbia.

- **In the field of protection, regulation and sustainable utilisation of the natural heritage:** develop the Programme of nature protection of the Republic of Serbia for the period 2021-2023, mid-term protection plans, state of the nature reports; long-term biodiversity protection plan;

- **In the field of protection, regulation and sustainable management of landscapes:** conduct the study of landscapes in Serbia (with the Atlas of landscape types of Serbia), develop projects for utilisation of cultural landscapes, projects of typologies of rural landscapes of Serbia, projects of networks of urban niches – high quality public spaces in cities, and a catalogue of indicators for monitoring the state of landscape character;

- **In the field of adaptation to climate change:** develop the Strategy of low-carbon development with an action plan: programme of interdisciplinary research of climate change and its impacts on different sectors; identify zones susceptible to extreme weather and natural disasters and develop regional and local natural disaster risk maps; develop national plans of adaptation to changed climate conditions; sectoral plans and programmes of measures for climate change adaptation and mitigation; and flood protection plans;

- **In the field of disaster risk reduction and emergency management:** develop a cadastre of disaster susceptibility for Serbia.

3.5.9.4. Proposals of the highest legal act to regulate windbreaks in the Republic of Serbia

In line with the analysis of the issue in the Republic of Serbia and positive experiences in other countries, there is a need to draft the highest legal act regulating the issue of windbreaks in the Republic of Serbia, specifically the *Law on Establishment of Windbreaks in the Republic of Serbia*. Such an act would define windbreaks as assets of national interest, in state, municipal or private ownership. Thus, the system of protective windbreaks is treated as a public asset, under the jurisdiction of national authorities in the field of forestry and/or environmental protection.

The adoption of such highest legal act would create conditions for the development of the „Master plan of protective forest windbreaks system", which would, after its adoption, be integrated into spatial-planning documents, at national, provincial, district and local level. This would be followed by developing relevant technical documentation (designs) for execution of works in accordance with the *Law on Planning and Construction*, where windbreaks would be treated as bio-technical facilities.

3.5.10. Cost estimate and time dynamics for establishment of the windbreaks system in Serbia

It is estimated that it is necessary to establish about 250,000 ha of protective forest windbreaks in the territory of the Republic of Serbia, of which about 150,000 ha in AP Vojvodina and about 100,000 ha south of the Sava and the Danube rivers. The establishment of windbreaks is necessary: primarily in flat regions with significant complexes of arable land; along road and railroad infrastructure; along the Dunav-Tisa-Dunav canals system; in the vicinity of urban centres, as an extension/link with the urban „green" infrastructure; around landfills and tailings ponds; in hilly-mountainous regions, in the vicinity of water accumulations used for public water supply, in form of ilo-filter belts.

It is estimated that the total area of municipal windbreaks in flat regions of Serbia should be about 230,000 ha, and in hilly-mountainous areas about 20,000 ha. Taking into consideration that the average cost of afforestation per 1 ha in hilly-mountainous areas is EUR 2,200 (using container seedlings, with planting density of 1,500 seedlings per hectare) and in flat areas the cost is EUR 1,800 the total cost-estimate is EUR 506,000,000 (for flat areas), and EUR 36,000,000 (hilly-mountainous areas), totalling EUR 542,000,000. If adequate legal solutions are developed, along with spatial-planning and technical documentation, identification of entities in charge of planned activities and if the necessary funding is ensured, the systemic activities can begin in 2025. The realistic annual dynamics of establishing windbreaks is 25,000 ha annually, with investments of about EUR 50,000,000 meaning that ending with 2034 the process of establishing windbreaks across the whole territory of the Republic of Serbia would be finalised.

A more accurate cost estimate, with details records of planned areas of municipality under windbreaks can be presented only after the adoption of the *Law on Establishment of Windbreaks of the Republic of Serbia* and after development of planning and technical documents.

4.

Final considerations

Forest windbreaks are necessary in order to achieve the following goals: protection of arable land against wind erosion; protection of the DTD canal system against drifts from wind erosion; protection of the road and railroad infrastructure against snow drifts; protection of settlements against pollutants travelling during wind episodes; visual isolation of communal landfills and disposal sites; protection of water areas (lakes, ponds); protection of facilities significant for beekeeping; establishing plantations for production of biomass for energy generating purposes; establishing corridors for biodiversity rehabilitation and protection; establishing sports-recreational infrastructure within the windbreak system (cycling and pedestrian tracks, outdoors exercise grounds, resting places, educational tracks, children playgrounds, contents for persons with disabilities; linking urban green infrastructure with the existing and planned windbreak belts; networking of belts into systems of „blue-green“ and environmental corridors); protection of settlements against noise and pollution.

So far the Republic of Serbia has not utilised its potential for the establishment of windbreak belts, which has resulted in major damages for the sectors of agriculture, forestry, water management, road and railroad infrastructure, nature protection, tourism, sports and recreation. At the same time, lack of windbreaks denies beneficial ecosystem services to the whole communities in the domains of mitigating effects of climate change, rehabilitating and preserving biodiversity, quality environment, particularly protection of settlements against pollution. Wind erosion is dominant in the whole territory of AP Vojvodina, as well as in flat areas south of the Sava and the Danube rivers, with particularly susceptible regions being western parts of Srem and Bačka, lower areas of southern Banat, upper Pomoravlje, Vranje with its surroundings and the Braničevo district.

The general requirements related to the establishment of windbreaks are regulated in the valid national legislation (the *Law on Forests*, the *Law on Agricultural Land*, the *Law on Waters*, the *Law on Roads*), but this is done in a fragmented manner, not enabling comprehensive consideration of the issue and undertaking adequate activities. The strategic directions of the current spatial-planning documentation („Spatial Plan of the Republic of Serbia 2010 - 2020“; „Regional Spatial Plan of AP

Vojvodina until 2020") clearly underline the need to increase the level of afforestation of the national territory, partly by establishing windbreaks. The draft „Spatial Plan of the Republic of Serbia 2021-2030" recognises the significance of windbreaks.

The issue of windbreaks is also complementary to the activities implementing the „RIO" conventions (UNFCCC, UNCCD, UNCBD), the „2030 Agenda for Sustainable Development", the Sustainable Development Goals, particularly SDG 15 („Life on Land"), and the adopted national report on „LDN - Land Degradation Neutrality (2019).

The spatial coverage, the significance and the multifunctionality of the windbreaks system requires the establishment of an independent management unit, in form of a public enterprise or a company, under the control of the Ministry of Agriculture, Forestry and Water Management and/or the Ministry of Environmental Protection. Financing activities is possible partly from the national budget or international funds (to which Serbia has access), and partly from collecting fees from users utilising the benefits of windbreaks (agriculture, water management, road and railroad transport, energy generation). Funds resulting from collected fees should be used for ear-marked purposes, exclusively for financing of existing windbreaks and planning, constructing and maintaining new ones.

In accordance with the presented facts and the accompanying analysis, it is recommended to implement the following measures:

- Drafting and adoption of the *Law on Establishment of Windbreaks of the Republic of Serbia* (hereinafter: the Law); the Law shall define windbreaks as a general asset or facility of national interest, under the jurisdiction of the authority in the area of forestry and/or environmental protection;
- Regulate by the law the classification of protective forest windbreaks, depending on the significance (state-owned 1st and 2nd class; municipal);
- Regulate by the law the models of managing protective forest windbreaks (state-owned 1st class windbreaks to be managed by public enterprises or a company owned fully by the Republic of Serbia; state-owned 2nd class windbreaks or parts of 2nd class windbreaks, located in the territory of the autonomous province to be managed by public enterprise of company fully owned by the AP; municipal windbreaks, which are not part of state-owned 1st or 2nd class windbreaks, may be managed by public enterprise or a company fully owned by the unit of local self-government or another company or entrepreneur to whom the local authority has delegated the activity of managing municipal windbreaks, in accordance with the law regulating public-private partnership and concessions; state-owned forest protective windbreaks may be managed also by institutions which managed such

a windbreak until the day of coming into effect of the law regulating windbreaks, provided that they fulfil the requirements prescribed by law and special regulations, state-owned forest protective windbreaks may be managed also by a state-owned public enterprise or company founded by a unit of local self-government which managed such a windbreak until the day of coming into effect of the law regulating windbreaks, provided that they fulfil the requirements prescribed by law and special regulations);

- Regulate by the law the procedure for leasing of the necessary areas of municipality, exclusively from the point of view of functionality, irrespective of ownership type. With respect to private property, ensure a permit for change of intended use, conduct the purchase (with adequate compensation) or with just land substitution, preceded by parcelisation, re-parcelisation, land consolidation or expropriation.

- Windbreaks can be the property of the state, municipality or private property;

- Prescribe sanctions for any act aimed at destroying or damaging windbreaks;

- The adoption of the law is followed by the development of the „„Master plan of protective forest windbreaks system“, which would, after its adoption, be integrated into spatial-planning documents, at national, provincial, district and local level;

- Identification of windbreaks in spatial plans will enable the development of relevant technical documentation (designs) in accordance with the *Law on Planning and Construction*, where windbreaks would be treated as bio-technical facilities;

- In the course of drafting and adopting the law, initiate the development of the „Cadastre of national windbreaks system“, including existing and future belts, with a representative data base on all key characteristics of windbreaks, in GIS software environment;

- Develop the missing strategic documents: „Strategy of prevention and protection against wind erosion“ and the „Erosion Map of Serbia“;

- Ensure a multi-sectoral approach in considering the issue, in developing the planning and technical documentation, as well as in funding, with active involvement of the sectors of agriculture, forestry, water management, road and railroad infrastructure, energy generation, environmental protection, managing protected areas;

- Projects are to be implemented by forestry engineers, licensed in land erosion protection and establishment of windbreaks, along with other relevant expert profiles (spatial planners, geodetic engineers, agriculture engineers, landscape and horticulture engineers, engineers of geology, biologists);

- Ensure the participation of local authorities and the civil society sector in all stages of developing the planning and technical documentation;

It is estimated that it is necessary to establish about 250,000 ha of windbreaks across the whole territory of the Republic of Serbia, of which about 150,000 ha in AP Vojvodina and about 100,000 ha south of the Sava and the Danube rivers. The estimated financial needs amount to EUR 542,000,000 for the whole territory of the Republic of Serbia, for the period 2025 - 2034. A more accurate cost estimate, with detailed records of planned areas of municipality under windbreaks can be presented only after the adoption of the Law on Establishment of Windbreaks of the Republic of Serbia and after development of planning and technical documents.

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50. Strategija razvoja šumarstva Republike Srbije, 2006 Ministarstvo poljoprivrede, šumarstva i vodoprivrede, Uprava za šume;

Appendix

Interviews with representatives of institutions (the Ministry of Environmental Protection, the Ministry of Agriculture, Forestry and Water Management, and other relevant institutions and organisations) and collection of data relevant to windbreaks

In order to identify the positions of relevant decision-makers and managers, a survey was conducted among employees in public administration and public enterprises. All respondents are technical staff in the field of forestry, highly qualified, with many years of professional experience. Their positions are of relevance for the process of formulating proposals for methods of planning, financing and managing windbreaks in the Republic of Serbia. Below is an overview of positions of professionals from the selected institutions who participated in the anonymous survey.

1. Which institution do you come from?

A. City Administration of Belgrade, Secretariat for Environmental Protection (1 respondent);
B. The Ministry of Environmental Protection of the Republic of Serbia (1 respondent);
C. The Directorate for Forestry, Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (1 respondent);
D. JP “Srbijašume” (2 respondents);
E. JP „Vojvodinašume“ (1 respondent);
F. Provincial Secretariat for Environmental Protection (4 respondents);
G. Provincial Institute for Agriculture, Water Management and Forestry (1 respondent).

2. How should the establishment of windbreaks be organised: based on projects by units of local self-government and regionally or on the basis of a comprehensive national programme for the whole territory of Serbia?

A. In the planning process there should be a clear strategy for the whole territory of Serbia, while in the process of programme implementation there could be cooperation with units of local self--government;

B. By a harmonised approach integrating all three above methods;

C. Depending on the specific features of each part of the territory of Serbia. Certainly the establishment of windbreak belts at local level require regional/national programmes to be in place;

D.1. First the National forestry action plan of the Republic of Serbia should be developed, followed by programmes for the establishment of windbreaks harmonised with the Master urban development plan and detailed regulation plans at the level of units of local self-government;

D.2. In all of the above ways, but ensuring some coordination;

E. In case of windbreaks along roads or agricultural land it should be done based on projects developed by units of local self-government, but with the support of national institutions. There is potential collision with the sector of agriculture;

F.1. Both. First, develop a comprehensive national programme. Since these actions are most needed in the territory of AP Vojvodina, this should be accompanied by a document at the provincial level. All of it should be integrated in the spatial planning documentation. This should then be followed by developing programmes and projects at local level;

F.2. Comprehensive programme;

F.3. Projects at the level of local self-government and regional ones, preceded by resolving the issues of ownership or the issue of who is in charge of management. Practice from the 1990's indicated that without the managing entity, anyone can cut down parts of windbreaks for their own needs without consequences;

F.4. The Master plan should provide the framework at national level, in line with the prevailing regulations, while regional and local levels can ensure adjustment to climate conditions (hilly or flat regions, regions with different levels of precipitation, etc.).

G. On the basis of a comprehensive national programme.

3. Who should be in charge of managing the existing and planned windbreaks?

A. The existing and planned windbreaks should be managed by legal entities having technical and expertise capacities for this type of activity. In addition to the public enterprises „Srbijašume“ and „Vojvodinašume“, managing entities can also be water management companies, companies engaged in road infrastructure and the like, both at national and at local level, preceded by raising capacities for activity in the field of forestry. Additionally, big polluters (industrial and energy generating facilities, sanitary landfills) which are obliged to establish windbreaks can also be the managing entities, but with clear guidance for the maintenance process, because only properly managed windbreaks

can fully achieve their intended function. Public utility companies, founded by units of local self--government, are often in charge of managing windbreaks in urban areas;

B. Technical organisations but also institutions, in coordination with the relevant ministries;

C. Enterprises at local level, if any. Certainly, in accordance with the *Law on Forests*, but it should not be public enterprises for forests management;

D.1. Beneficiaries in line with the current situation (public enterprises, public utility companies). There should be a control body at national level which would be engaged in planning, establishing and maintaining windbreaks, such as the Forestry Council, in accordance with the *Law on Forests*;

D.2. The responsible institutions, organisations and enterprises in charge;

E. This would depend on the type of windbreaks. It is very important to differentiate the term of FOREST from OTHER FORESTRY GREENERY and/or "GREENING" OF URBAN ENVIRONMENTS. In that respect, if it is related to forest complexes it would be the public enterprise in charge of forest management. If it is related to windbreaks along roads and agricultural areas, it should certainly be the local self-government (some type of organisation within the units of local self-government or enterprises as city parks);

F.1. It is best if these windbreaks are managed by units of local self-governments, or some local actors having capacity for this function. Where possible, it should also be the public enterprises for forestry, or some combination;

F.2. Forest management entities, such as JP „Vojvodinašume", JP „Srbijašume" and JP National Parks;

F.3. Units of local self-government in their territories, with the involvement of the higher level (provincial, national);

F.4. Professional state organisations registered for forest management.

G. Special units/branches of JP „Srbijašume" and JP „Vojvodinašume", or even better separate enterprises, because of the risk that in the said public enterprises this function could get lost among other "more important" obligations.

4. How do you perceive the role of windbreaks in mitigating effects of climate change?

A. Windbreaks are part of the green infrastructure and, as such, they have a great role in mitigating the effects of climate change, such as: reducing effects of urban „heat" island; reducing the intensity of wind erosion processes; reducing risks of flash floods; protection of road infrastructure against snow drifts. Windbreaks are natural carbon-dioxide „reservoirs", which is important in terms of greenhouse gasses and mitigation of climate change. Well planned and designed windbreaks can be a passive energy efficiency measure and may contribute to reducing harmful gasses in the environment;

B. Reducing the carbon-dioxide in the atmosphere;

C. Very positive role, not only in mitigating climate change, but also in combatting desertification;

D.1. Very significant. Forest both in spatial and temporal sense (the micro plan) contribute to mitigating the negative effects of climate change;

D.2. Multiple benefits from a number of different aspects;

E. Certainly a positive role and in line with the great number of functions that forests provide (forest have more than 300 different functions, the most important being the carbon sink function and

the protective regulatory roles in land, water and air regimes). It is particularly important to select appropriate tree species for this purpose, depending on the available habitat (the locations where their establishment is planned),but also such species which can survive in semi-urban and urban environments so as not to be under risk of air pollution of traffic;

F.1. This role can be significant, but the key is to seriously and responsibly resolve the issue to planting material, locations for planting (much of the cadastre area along farming land and canals is abused by farmers, etc.), ensure long-term maintenance and care, permanent supervision. Without this no positive impacts will be achieved either on climate change or biodiversity or landscapes. It is also important to prevent malpractices (sale of poor planting material, unqualified planting, steeling of seedlings, misrepresenting the actual situation in the field ...). Serious state control is needed for everything that is done in this respect at local level and specific measures are needed against those entities who do not establish such belts in accordance with the designs of who subsequently destroy them;

F.2. I am not qualified to talk about climate change;

F.3. Forest windbreaks are irreplaceable in mitigating climate change. Creating microclimates in the areas sheltered by the windbreaks results in reduced evaporation from the arable land, prevents wind erosion on arable land and thus reduced use of artificial fertilisers which also results in preventing pollution at a number of levels;

F.4. The less afforested the area and the less natural area there is (forest, pasture, meadow), the greater is their role, and it is important for carbon capture and as a climate-protective belt in the vicinity of settlements, but also for the survival of wild animals which also suffer the consequences of climate change;

G. It is positive to some degree, but not as much as expected from it. Climate change is a global phenomenon and a much broader problem. The role of this belt is more of environmental nature at local level (better air quality, less erosion, more attractive landscape ...).

5. How do you perceive the role of windbreaks in rehabilitating biodiversity?

A. Intensive urbanisation has led to fragmentation of habitats, which disables migration of different species, so that in addition to windbreaks being part of biodiversity they also have a very valuable role in linking habitats and enabling species migration;

B. It is a contribution to preserving biodiversity;

C. Limited positive role; windbreaks will have a greater role as environmental corridors;

D.1. Windbreaks have a positive effect on renewing biodiversity. They can be a natural habitat for plants and animals;

D.2. Windbreaks increase biodiversity;

E. Every tree, and particularly a group of trees is a complex formation or biogeocenosis which affects its environment. It increases the biological wealth and is a potential habitat for other species such as insects, birds, etc. it certainly supports the increase of the biological potential qualitatively and quantitatively, which is very important;

F.1. It is an extremely important role for landscape diversity as well as environmental corridors which link isolated and semi-natural habitats;

F.2. They have a significant role, both in rehabilitation and in preserving the existing biodiversity. Primarily as corridors and habitats for numerous species, not so much forest species, but more forest-steppe species;

F.3. In Vojvodina, where arable land was extended at the price of all other types of habitat, the windbreaks would certainly contribute to improving biodiversity, starting from being excellent substitute habitats for species. They would also be good environmental corridors linking habitats in a manner which would contribute also to genetic diversity of species;

F.4. Windbreaks have a twofold role: as habitats and as corridors. As corridors they should provide a link between preserved forest corridors. In agricultural areas they have an important role in preserving the wild forest-steppe species and as a shelter in the winter period. They generally contribute to improving biodiversity provided they are not established by removing natural habitats (ex. in natural grassland, which in Vojvodina now have a share of only a few percentages);

G. Positive to some degree, but not as much as expected. It is hardly likely that windbreaks would be established with types of trees that would contribute to diversity, because that is very difficult. It easiest, despite everything, is to establish tem with types of trees which are most frequent in the forest and non-forest greenery (although in that case there is the question of their efficiency). In any case, in Vojvodina they would contribute to rehabilitating biodiversity by the mere fact that farming land is intersected with something else.

6. How can the potential of windbreaks be used to establish sports and tourism-recreational contents?

A. Windbreaks can be seen as green corridors, spreading in a linear manner along watercourses and road infrastructure, and with adequate landscape and architectural interventions they can be pleasant sites for stay and recreation and can contribute to the quality of life of the local population and increase the tourism supply. They are ideal for cycling, hiking and exercise tracks, smaller open air exercise grounds and resting places;

B. By defining such contents depending on the biological-environmental characteristics of windbreaks;

C. It can be used so that these belts, as corridors, link certain tourism locations and they can be used for recreational tourism;

D.1. Adequate planning can utilise the functions of windbreaks for sports and recreation. It is recognised that windbreaks reduce the speed of wind, increase relative air humidity, mitigate temperature extremes (in the summer the forest cools the air), which is ideal for tourism and engaging in sport in such micro-environments;

D.2. Plan windbreaks so as to serve also the recreational purposes;

E. In forestry terms, protective windbreaks certainly do not have the basic production function. The key purpose is protective-regulatory, but in case that the location and position of windbreaks allows (that it is not along roads, etc.) they could be the ideal place for sports and recreation contents as

activities in nature. At present, sports and recreation of that type are very popular in line with the urban (accelerated) way of living and stress resulting in everyday lives of urban populations;

F.1. I suppose in for of pedestrian/hiking tracks ...;

F.2. It is good in the vicinity of settlements, while further away from settlements it is in collision with the function of preserving biodiversity. They are not good for kite flying, but two trees can very well be used to play football as they serve as goal posts;

F.3. The visual effect of such windbreaks is quite suited for cycling tourism and hiking tours, the windbreaks will also be habitat for strictly protected species, therefore for bird watching, etc.;

F.4. By increasing landscape biodiversity, providing shading and reducing extreme temperatures, they will enable the construction of cycling tracks and their integration into cycling routes linking the whole of Europe. They can also offer recreational contents of local significance such as exercise tracks as the like.

G. That is a great potential. For example, in parallel to them, cycling tracks, hiking/pedestrian tracks, resting places, camping sites can be provided and that would be even greater in case that the windbreaks are in the vicinity of some existing tourism-recreational facilities, even if they are very small, local, less known, etc.